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LET US ECONOMIZE IN FERROUS METALS

Translated from Metallurg, No. 6, p. 1, June, 1960

"Izvestia" of March 2, 1960 published an appeal by the Metallurgists of the Kuznetskii Metallurgical Combine to all steel-industry employees to organize a socialist competition in the economical use of pig iron, ferroalloys, metallic charge and steel which go into production of each ton of finished rolled stock. The Kuznetskii metallurgists have committed themselves to ensure economical use of metal in all stages of metallurgical treatment. The Combine's steel workers have obliged themselves to reduce the metallic-charge demand for producing one ton of open-hearth steel to 1072 kg; this they would do by reducing rejects, incompletely poured-ingots, waste and trimmings. During the current year, such reductions would save eight thousand tons of metallic charge over and above what is planned.

Rollers have decided to reduce ingot consumption per ton of rolled stock by means of reducing waste, poor finish, inadequate meeting of dimensional tolerances, trimming, as well as reducing rejects because of edge and internal faults. All this will enable the combine's workers to produce 10,000 tons of finished rolled stock in excess of the annual plan during the current year.

The Kuznetskii metallurgists have committed themselves to achieve the following: reduce steel consumption per ton of rails, high quality structural steel and pipe; to make the use of more economical rolled shapes more widely accepted in the national economy and to increase their production to 355,000 tons – this in itself will make available to the country 2.5 million additional tons of beams and channel irons; to improve the methods of controlling metal structure with the help of ultrasonic methods; organize in the departments scrap-metal collection which would yield 50,000 tons of metal over and above the annual plan; and to recover from slag rejects 60,000 tons of scrap.

Collection of scrap metal is an important reserve for increasing steel production. If the annual quota of scrap-metal collection is exceeded only by 1%, production of more than 200,000 additional tons will be possible. Regrettably thousands of tons of scrap metal are rusting away because of negligence of some industrial bodies. The managements of metallurgical concerns, and party, Union, and Komsomol organizations should improve significantly the collection, sorting and treatment of all forms of ferrous scrap metal.

The Central Committee of the Union of Metallurgical Workers approved the valuable initiative of the Kuznetskii Metallurgical Combine and decided to spread it to all metallurgical concerns in the country.

On April 22, 1960 the Central Committee of the Communist Party of the Soviet Union appealed to all our country's plants through the central newspapers to follow the Kuznetskii metallurgists' example.

The letter says "The Central Committee of the Soviet Union believes that the party, soviet, economic, labor-union and Komsomol organizations. . .all workers of our country, after considering this letter, will do all possible to achieve a substantial economy of ferrous metal. This will enable providing the national economy with pig iron, steel, rolled stock and tubes, will further enable a quicker pace along the path of technological progress and will favor an even more successive development of the national economy and building of a Communist society in our country."

* * *

BASIC TRENDS IN THE DEVELOPMENT OF FERROUS-METALS TECHNOLOGY

Translated from Metallurg, No. 6, pp. 2-8, June, 1960

The next 10-15 years will be marked by a sharp growth in the overall volume of production of the USSR's steel industry as well as by a significant change in the direction and character of its development.

The editors of the journal "Metallurg" have asked the leaders of the foremost research and engineering institutes to discuss the basic trends which are the subject of these institutes' work.

Below we publish the replies we received from the editors.

HOW METALLURGICAL PROCESSES WILL DEVELOP

Doctor of Techn. Sci. V. I. Karmazin

Mekhanobrchermet

The unavoidable presence in the blast furnace process of a large quantity of rock which is unproductive and occupies furnace space, and which requires increased coke consumption for its smelting, exerts a significant influence on the manufacturing cost of pig iron. Although removal of this rock in the beneficiation process decreases the smelting cost by a factor of a few times, yet a part of the rock always remains in the ore and forms a slag. At the present time the silica content in concentrates resulting from beneficiations has not reached a level where it is just sufficient for forming the slag only.

Even now new more effective trends and processes are being contemplated in metallurgy; these are based upon high-quality raw materials which can be provided by the newest beneficiating technology. One of these is the so-called nonblast-furnace or direct production of pig iron ; this is a process in which it is possible to use the large reserves of natural gas and cheap, low grade coal in place of the expensive coke.

Direct reduction presupposes a continuous, fully mechanized, easy to control and automated production of metal. This metal in the form of pellets would then be used instead of scrap directly in the open hearth and electric furnaces. Production of metallic powders, pellets or ingots without outlays for expensive coke will not only make steel production cheaper but will also simplify the smelting technology. Moreover, it has been proven that steel produced from nonblast-furnace metal will show better mechanical properties than common steel.

The "direct" metal will be a more valuable product for smelting high-quality steels. The richest sponge iron – that which contains less than 0,5% impurities – will find use in the new, rapidly developing, field of metalloceramics. A very effective use of sponge iron is in the form of a cooler in the finishing stage of the converter process. With the help of direct reduction it is also possible to obtain strips which can be sent directly to the rolling mills. Work concerning direct reduction of iron in the USSR is basically still in the laboratory and semi-works stage. Presently effective methods of controlling the process are being investigated and most rational furnace designs are being engineered.

The pyrometallurgical and direct-reduction laboratory of the "Mekhanobrchermet" Institute (director of the laboratory is G. V. Gubin, Cand. of Techn. Sci.) is working on the design of fluidized-bed furnaces for direct reduction of ores. Use of the fluidized-bed principle will make possible obtaining a high-productivity plant with a low capital investment for equipping it. Investigation is in progress concerning rational use of natural gas for heating ores and for reduction in furnaces: both magnetizing roasting and as direct reduction to iron. Also being studied is the mechanism and the kinetics of reduction with natural gas.

The work has shown that it is possible and expedient to use direct reduction at present. Thus using this process, together with magnetizing-roast concentration, it is possible to obtain a very valuable metallurgical raw material from the Kerch "tobacco" ores which are presently not mined because of difficulties of beneficiation. The fact that such a preparation is economical hinges on subjecting to direct reduction only the difficult-to-beneficiate fraction – the finely divided intermediate product of the magnetizing-roast concentration. The iron content in the concentrate after direct reduction reaches 90% and higher.

In addition to these studies, the institute is carrying out investigations in the field of thorough concentration of the ores. The purpose of these investigations is to obtain the maximum increase in the quality of the metallurgical raw material by means of concentration. This is necessary for intensifying the blast-furnace process and for a more efficient use of metallurgical equipment. Moreover, on the basis of high-quality raw material we

facilitate the introduction of new metallurgical processes, for example, the extraction of scrap from ores for steel production and, the direct production of iron with special properties. The introduction of thorough concentration of iron ores and the use of high-quality raw materials in metallurgy must be accomplished as soon as possible since in a very short time this will produce an enormous economic effect. Thus, under conditions of the southern metallurgical plants 0.8 t coke and 1.5 t of limestone with a total cost of 200-275 rubles/t are required to convert 1 t of silica to slag in a blast furnace.

A total of 26-95 rubles/t is spent to remove such an amount of silica from the ore at the concentration factories (i.e., by mechanical separation without heating and smelting). In addition to this, the increase in the productivity as a result of releasing the blast furnaces and open-hearth furnaces from smelting the excessive amount of slag will make it possible to save up to 70 rubles/t of the annual productivity (under the condition of increasing the iron content in the concentrate from 59 to 66%). If we also take into consideration the increase in the productivity of the furnaces as a consequence of the high-quality charge, the savings for a total of 50 million tons of pig iron smelted in the USSR will be expressed in billions of rubles and hundreds of millions of man-hours. Thus, the calculations show that by using a concentrate containing 66% iron and 7% silica (as compared with the concentrate containing 59% iron and 15% silica) the cost of pig iron will be reduced 23-25 rubles/t, the productivity of the furnaces will increase 14%, coke consumption will decrease by 58 kg/t of pig iron.

Introduction of these processes will solve the problem of utilizing the large reserves of oxidized quarzites. Numerous designs of equipment for concentrating magnetites and calcined ores in the dry state are being developed. These designs are based on the centrifugal magnetic separator. Application of dry methods of separation reduces sharply the concentration costs; this because of increased equipment capacity and a smaller number of auxiliary operations.

High-quality concentrates should be prepared for metallurgical treatment with the help of pelletizing. Pre-fluxed pellets will enable the complete elimination of the flux from blast furnaces, a fact which will permit the reduction of coke consumption even more. In transportation pellets behave better than any other raw material. At present, the agglomeration laboratory at the institute (I. I. Rovenskii, director) is developing effective methods of producing fluxed pellets possessing good strength and reducibility.

New processes for beneficiating marginal ores using heavy-media separation are being developed. Good prospects are flotation and hydrometallurgical treatment of manganese slimes which are, presently, thrown out to the dumps at the beneficiation plants. Flotation in conjunction with hydrometallurgy eliminates practically completely the losses of costly metal in the slimes. Solution, by the institute in co-operation with other concerns and institutions of the complex of problems dealing with the concentration of iron ores to high purity will doubtlessly set the groundwork for a quicker introduction and development of new metallurgical processes.

WHAT THE TsNIIChM IS WORKING ON

N. M. Lapotyshkin, Scientific Secretary TsNIIChM

In accordance with the decisions of the 21st Congress and the June Plenary Session of the Central Committee of the Communist Party of the USSR, the Central Ferrous Metallurgy Research Institute (TsNIIChM) changed its work in a radical way.

Some projects were turned over to other research and teaching institutes or plant laboratories; as a result it was possible to concentrate at TsNIIChM on the solution of such weighty problems as: mechanization and automation of metallurgical undertakings, development of new metallurgical processes, finding steels and alloys for new technologies, solution of problems in the development of the theoretical base of metal production, strength and high-temperature strength and steel-alloying theory.

The decision of the USSR Council of Ministers foresees action in the field of complex mechanization and automation of production processes at a series of large metallurgical plants. TsNIIChM will be in charge of developing and introducing complex mechanization at the following metallurgical combines: Magnitogorsk, Kuznetskii, and Nizhne-Tagilsk.

In the course of 4-5 years the shops in these plants will become pilot operations with respect to mechanization and automation. The best experience will then be widely used at other ferrous metallurgy operations. In this connection TsNIIChM together with other institutions will, during 1960, be active in 18 research projects dealing with complex mechanization and automation of the agglomerating, blast-furnace, and rolling-mill processes. In the solution of these problems the working conditions will receive much attention.

In order to automate a metallurgical process it is essential that physiochemical methods of analyzing the metal during the course of its melting be developed. In this area it is essential that the most universally applicable method be used; this is the photoelectrical spectral method coupled with the use of quantometers, and the pneumatic transport of samples to the laboratory.

The above work is also conducted at the institute. In addition the institute develops some new tools; among these is the automatic thickness measurement on a hot sheet, and measurement of temperature of molten steel.

Beside the work dealing with mechanization and automation TsNIIChM will conduct a series of other research efforts, the more important of which are as follows:

Use of natural gas and oxygen in the blast furnaces at the "Zaporozhstal'" plant and other metallurgical plants;

Perfection and wide application of steel production in a converter by blowing with oxygen;

Removal of silicon and sulfur in the 1300-ton mixer at the "Zaporozhstal'" plant;

Refining of converter and open-hearth steel in ladles using synthetic slags at the KMK and NTMK;

Bringing into production the process of melting in the electric furnace in the presence of slag for the production of precision-quality ball-bearing steel and type 1Kh18N9T steel for thin-walled tube;

Introduction of continuous casting and production of transformer steel at the Novolipetsk metallurgical plant;

Start up of the continuous casting machines at the Stalino metallurgical plant;

Production of high-quality transformer steel in straight-through thermal furnaces at the Novosibirsk metallurgical plant;

Work concerning reduction in consumption of nickel and other scarce alloying elements; also introduction of other stainless and heat resisting steels;

Development and introduction of new precision alloys with specific properties;

Among the subject-matter of the institute's work are also efforts which reflect the nature of metallurgical processes of the near and the more distant future. These are:

Theoretical and experimental work concerning direct reduction to iron, a process which will be gradually pushing out the blast-furnace process;

Perfection and wide application of steel production in converters by blowing with oxygen;

Development of a steel smelting process which would be new in principle and which would be based on continuous equipment. Theoretical aspects of this process have already been worked out and at present the experimental work on a semi-works scale is underway;

Theoretical and experimental work dealing with problems in vacuum metallurgy which should pave the way for successful introduction of vacuum metallurgy into industry;

Development of the method of influencing the crystallizing processes in the metal by means of ultrasonics.

This work is, in essence, a scientific and experimental preparation for the development of metallurgy along new technological paths.

A significant place in TsNIIChM's work is occupied by research into metallurgical-process theory, metal physics, and also application of the achievements of nuclear physics in metallurgy. Our investigators are active in the following fields: theory of hardening and annealing of steel, theory of martensite transformations, equilibrium distribution of elements between the metal bath and slag in the smelting process, kinetics of metallurgical reactions, utilization of synthetic radioactive isotopes in the study and control of metallurgical processes; all these investigations are of great significance in the growth of metallurgical theory.

One of the new and most promising areas of theoretical research at one institute is the work on obtaining defect-free metal crystals showing strengths approaching the theoretical.

Very important are economic studies conducted by the Institute. Many central institutions and organizations rely on the results of these studies. The main objective of the technico-economic investigations is the study of internal as well as interindustry economic problems of ferrous metallurgy. In the next few years these problems will be studied not only from the standpoint of the over-all problems of ferrous metallurgy (raw material and fuel utilization, question of funds etc.), but also from the standpoint of proving the economic effectiveness of the new technology, process mechanization and automation and creation of new products.

In 1960 new standards and processing conditions for new steels and alloys will be worked out for the ferrous metallurgy.

This is the basic course which is followed by the staff of the Central Research Institute for Ferrous Metallurgy.

SOME ASPECTS OF THE WORK OF STAL'PROEKT

R. M. Mantsev, Director of Stal'proekt

Stal'proekt's job is to design steel-smelting plant equipment (open-hearth furnaces and converters), continuous-casting facilities, heating and heat-treating furnaces for the rolling mills, and also plants for protective-atmosphere manufacture.

As a result of the extensive assignments laid down by the party and the government to accelerate the growth and raise the technological level of ferrous metallurgy through new technology and complex mechanization and automation, work at Stal'proekt will be directed for the next few years toward the solution of a series of serious problems. The latter are related to prospects of perfecting plant equipment being designed at the Institute.

Steel-Smelting Plant Equipment

The basic tendency in the development of steel-smelting furnaces is the use of larger open-hearth furnaces and converters and top blowing with oxygen.

Use of 500-ton open-hearth furnaces lowers steel production costs by 4%, as compared to 185-ton furnaces and raises labor productivity by 30-35%.

At present Stalproekt is studying previously constructed 500 and 600-ton open-hearth furnaces and is designing new and larger furnaces with a capacity of 800-900 tons.

Steel production in converters lowers capital requirements by 40% as compared with production in an open-hearth shop of equal capacity.

In 1960 plans for a typical converter shop of 1.6-2.0 million annual tons capacity will be complete. The shop will contain 75-100 ton converters for blowing pig iron with oxygen from the top. The next stage in this field is the design of converters with a capacity of 200-250 tons.

Facilities for Continuous Casting of Steel

Continuous casting of steel increases annual rolled-stock production by 5-10%, improves rolled-stock quality, and reduces raw material consumption. With it comes the possibility of complex mechanization and automation of the ingot pouring process.

It is planned to introduce during the next 10-15 years continuous-casting facilities, first of all, in the existing plants where the ingot pouring is still done in pits.

At present Stalproekt is participating in the ironing out and study of the operation of the existing continuous steel-casting facilities. This includes the installation at the Novolipetsk plant which was designed by Stalproekt for turning out 150 × 600 to 170 × 1000 mm slabs; pouring was from a 90-ton ladle.

In addition Stalproekt is designing multistream installations for pouring ingots of 120-160 mm square cross section from 90-ton ladles, and for heavy ingots of 250 × 250 to 350 × 350 mm and 250 × 500 mm when pouring from 270-ton ladles. Development of such installations will permit the use of continuous casting, both in the existing plants with relatively small furnaces and in new plants with large steel smelting units.

Heating Furnaces in the Rolling Mills

The fundamental problem in this field is the design of high-capacity furnaces for the present day's large rolling stands. This includes the blooming mills with 4-6.5 million tons annual capacity. Also a problem is the design of furnaces in which metal loss by scaling can be significantly reduced.

Stalproekt is at present working on the design of compartmented soaking pits for high-capacity blooming and slabbing mills where each pit is heated by a single burner from the top. In order to reduce metal loss by scaling during ingot heating before rolling in the blooming mill, experimental, electrically heated pits are being planned. Scaling will be reduced by approximately a factor of 10.

Investigation of the operations of these experimental pits will supply data for subsequent design of industrial units of this type.

For the sheeting and rail-rolling mills Stalproekt will develop large, high-capacity continuous furnaces with five and six zones. Heating furnaces of a new design will be developed for the light-section and the strip mills of 250-300 ton/hr capacity. These furnaces will be either induction heated or combinations of continuous furnaces and rapid-heating sectional furnaces.

A series of furnaces for heating metal without oxidation prior to rolling will be developed in the near future. The first one among these is a continuous furnace for heating in an atmosphere consisting of incomplete-combustion products. This furnace will be built and tested at one of the plants in the Ukraine.

Heat-treating furnaces

The chief aim in the development of heat-treating furnaces is the design of continuous units for rapid nonoxidative heat treatment. These should in the next 10-15 years become the basic type of heat-treating furnace for thermal and thermochemical treatment of sheet. Continuous units will be employed also for large-scale heat treatment of steel shapes, including armature steel.

This year a design for a tower furnace will be completed at Stalproekt. This furnace is unique both from the standpoint of size and capacity. Its function is heat treatment of transformer steel according to the new technique.

For new cold mills and existing mills which are being converted to the spool method of production, a large number of single-stage, pit-type furnaces with a forced protective-atmosphere circulation under the muffle is being designed.

Stalproekt has much work under way dealing with the design of continuous furnaces for heat treatment of armature steel.

The most serious problem which must be solved in the next few years is the design of the following units:

A tower furnace for continuous bright annealing of tin plate. Tin plate treated in this type of furnace is characterized by a high quality and uniformity of properties as compared to tin plate heated in a cupola furnace;

A tower furnace for high-speed, continuous heat treatment of tin plate with an open flame. This type of furnace is, in comparison with the above type,

compact, dependable in operation and easy to maintain;

A unit for continuous, very high-speed bright heat-treatment of tin plate with heating and cooling the strip in molten sodium. Because heat transfer in molten sodium is very rapid this unit is very compact for its high capacity. In addition molten sodium cleans the metal surface and prevents its oxidation;

A furnace for the continuous hot-galvanizing unit. A feature of this furnace is the fact that in it, in addition to the heat treatment (tempering and normalizing), the surface is prepared for the application of zinc.

Presently a series of tests are underway concerning these units and the first stages of design have been reached.

Use of Natural Gas

The use of natural gas in open hearth, heating and heat-treating furnaces is of particular importance.

In order to solve this problem Stalproekt has designed an open-hearth furnace heated by natural gas and heavy oil, and also heating pits fired with natural gas. Work is underway on the choice of the optimum design for a continuous, natural-gas heated furnace, and also on the choice of the best system for recovery of combustion-products heat.

This work is in preparation for a far reaching introduction of natural gas as a fuel for metallurgical plants.

Complex Mechanization and Automation of Metallurgical Processes

Complex mechanization and automation of the production process is the fundamental route to increased labor economy and better product quality. Stalproekt is participating in a series of projects dealing with mechanization and automation of steel-smelting and rolling operations. Work is underway on mechanization and automation of heating-pit compartments and tin plate heat-treating furnaces using computers. A system of fully automatic control of protective atmosphere generators is being designed.

WORK OF GIPROSTAL ON THE INTRODUCTION OF NEW TECHNOLOGY

G. T. Litvinenko, Director of Giprostal

Presently the employees at Giprostal are working on problems of great significance to the growth of our metallurgy.

Development of the outside-of-blast-furnace pig iron desulfurization

A set-up for blowing lime into a ladle has been designed at the Institute. Plant-scale tests on this method of sulfur removal were conducted at the Enakievsk Metallurgical Plant. 50-70% of the sulfur was removed from the pig iron at a lime consumption of 12-15 kg per ton of pig iron. The process lasts 5-10 minutes and is introduced immediately after the pig iron is tapped into a ladle, i.e., virtually without disturbing the usual material flow of the process.

Introduction of pig-iron desulfurization outside the blast furnace will enable running the blast-furnace process on less basic slags, with a lower flux and coke consumption and will also increase blast-furnace productivity.

Increasing blast pre-heating

Use of a prepared charge and in part of pre-fluxed agglomerate permits raising the blast temperature and sharply reducing coke consumption. In order to further increase the blast temperature it is necessary to improve the quality of refractories used for lining the upper part of the air preheaters, replace the burners with larger ones and also increase the heating surface in the air preheaters.

In agreement with Giprostal high-alumina, ribbed brick for the lining will be produced at the Semiluk plant. The heating surface will be increased by 10-12% without increasing the volume.

It is imperative that the refractory industry learn how to produce a block lining with a honeycomb of holes, 35 mm in diameter,and which has an active surface 20-25% greater than the conventional lining.

Injection of Natural Gas into Blast Furnaces

A short operation of blast furnaces with use of natural gas has given very good results; it was possible to reduce coke consumption and increase furnace productivity. Even better results may be hoped for in the future. Particularly effective is the use of oxygen together with natural gas.

Design of higher-capacity open-hearth furnaces

In 1959 the employees of Giprostal completed designs for a super-large open-hearth furnace of 800 ton capacity. This furnace has the following features:

a) the relative area of furnace bottom per ton of charge has been increased,

b) a new design of the working-volume profile has been incorporated. It features front and back walls inclined toward the inside,

c) a single channel attachment has been provided,

d) slag-pocket and regenerator-chamber roofs are flat,

e) furnace-firing system is automatic,

f) low-exhaust-stacks; recovery boilers and exhaust cleaning is being provided.

Technical and economic indexes are more favorable for this furnace than for the 500 ton one. Productivity is higher by 19%, fuel consumption is lower by 8% and refractories by 23%; labor efficiency is higher by 12%.

Installation for preliminary oxygen blowing of pig iron with addition of ore and limestone

A design for such an installation was completed for the Azovstal' plant. Preliminary pig-iron blowing will enable raising the production capacity of open-hearth furnaces by 5-10% and lower the cost of steel. The cost reduction at the Azovstal' plant alone is up to 8.4 million rubles per year.

Typical schemes of mechanizing the cold repair work on open-hearth furnaces which were developed by Giprostal, have reduced the duration of overhauling a furnace by one to two days. Attendant cost reduction at every plant is up to 700,000 rubles per year.

Autocarburization of natural gas

A project to autocarburize natural gas was completed by the Institute. This has permitted discontinuance of use of heavy fuel oil in open-hearth furnaces using natural gas. Tests conducted at the Il'ich Works gave positive results and it is possible to introduce widely the autocarburization of natural gas.

A shot-blasting plant for cleaning sheets. In 1959 a project for continuous cleaning of sheets by shot blasting was worked out for the Alchevsk plant. Use of this method improves product quality and simplifies the sheet-cleaning operation. All work is mechanized and automated.

An installation for hardening stainless-steel sheets was designed by Giprostal in 1959 and put into operation at the Alchevsk Metallurgical Works. Here a series of new mechanisms was used, e.g., suction-cup pick-up for the sheets, furnaces with roller bottoms, tilter and hardening bath of new design etc.

Butt-welding machine

Giprostal completed a project of a butt-welding machine for the Stand 350-2 at the Makeev Plant. (The machine was designed by "VNIIMETMASh"). The machine increases the stand capacity by 10-25% and increases the output of good product by 1-1.5%. Use of such machines is readily feasible.

Automatic lines for centrifugal-casting of pipes.

The Institute has completed a design for an automatic pipe-casting line which includes centrifugal-casting machines, a stamp/worm machine, a form-making machine and also an installation for cleaning the pipes, coating them with asphalt, and others.

At present a radically new pipe-casting method is being worked out. This is the "siphon" process. Its introduction will cheapen and simplify production sharply and will also reduce capital outlay for equipping the shops.

In addition to the above enumerated subjects Giprostal is at present working on the development of a four-stream continuous steel-casting installation. Thereafter will begin the planning of a multistream machine which will turn the billets into a horizontal position.

Extensive work is underway at Giprostal on the subject of evaporative cooling of metallurgical units. At present more than 200 open-hearth, 5 blast and 12 heating furnaces have been converted to evaporative cooling. In 1959 only, 7547 thousand tons of steam were produced in the USSR by the evaporative-cooling installations. From this 78% was utilized and as a result it was possible to reduce operating costs by 110 million rubles.

In the next few years it is proposed to convert to evaporative cooling the majority of open-hearth furnaces, a series of blast furnaces and over 200 heating furnaces.

Much attention is being paid by the Giprostal staff to problems of automation of ferrous-metallurgy processes and also to the perfection of the design of metallurgical process units.

DEVELOPMENT OF AUTOMATION IN FERROUS METALLURGY

A. K. Adabashyan and B. M. Zvenigorodskii

Glavproektmontazhavtomatika (Chief Administration for the Design and Construction of Automatic Systems)

The Chief Administration for the Design and Construction of Automatic Systems is active in major research investigations, develops new means of automation and works out complex automation projects for ferrous-metallurgy plants.

For the beneficiating and crushing/sorting plants, the instruments for controlling the technological processes are being developed. Moreover the status of these plants with respect to complex automation and remote control when using computers, the new means of communication, television, etc., is being reviewed.

At the agglomeration plants the basic status with respect to complex automation and remote control is also being reviewed in cooperation with TsNIIChM (Central Scientific and Research Institute for Ferrous Metallurgy) and Mekhanobr. At present an experimental sintering installation featuring a completely automated process and an automatic control of agglomerate quality is being designed. Such an installation is to be tested in 1960.

TsLA and TsPKB together with TsNIIChM and other organizations are at present working on further improvements in the system of blast-furnace automation. Dynamic process characteristics are being determined and new control loops are being developed. Following is a part of what is proposed for the blast furnaces in the near future: to automate the distribution of blast to the tuyeres; to control the rotating distributor based on the temperature of peripheral

gases; to control charge-in alterations according to radial temperatures which would be measured under the charge level by means of traversing sound probes; to control the operation of the blast furnace based on blast pressure drops in the charge column; to measure temperature in the crucible through the tuyeres; to measure pig-iron and slag temperature at the outlet.

In the later stages, after a mathematical model of the blast furnace process has been developed, a computer will be used in the control circuit.

The organizations forming a part of Glavproektmontazhavtomatika (TsLA, TsPKB, Uralmetallurgavtomatika) are working together with TsNIIChM, the Plants KIP and Teplopribor and a series of others, on the development of automation tools and instruments for the control of the open-hearth smelting process. (Among these are: a pyrometer located under the roof, resin meter, differentiator for the measurement of checkerwork heat-up speed, an instrument for measuring the combustion-products temperature at the active furnace-chamber exit, a radiation-based instrument for measuring the temperature in the active furnace chamber, a method and the required instruments to measure bath temperature during the course of the heat, a corrective regulator for controlling the combustion process based on the measurement of the exhaust-gas oxygen content). Further work includes determination of mutual dependence of firing pattern and process behavior, e.g., temperature of metal and slag during the course of the heat, composition of metal and slag, and the rate of carbon burning.

In addition plans are being developed now at the MMK, NTMK, and the Dzerzhinskii Plant for an experimental installation of automatic control of the open-hearth furnace firing process. The installation is based upon research at the TsLA, TsPKB, Uralmetallurgavtomatika, and VNIIMT. In the project it is planned to have preprogrammed heat periods, automatic fuel input based on sensing the speed of checkerwork heat up and roof temperature, and regulation of the firing process according to the oxygen content of the flue gases.

Later to this installation will be added a regulator for the rate of fuel input which will automatically decrease the latter as the quantity of carbon monoxide evolved from the bath increases. Other additions will be instruments which control the rate of carbon oxidation, and automatic controls for oxygen blowing of the bath.

The continuous-casting installations will, in their turn, be equipped with instruments for metal-level control in the intermediate unit and in the crystallizer. Complex automation of this process requires improvements in the design of the pouring machines and the stopping mechanism, and a complete mastery of the pouring technology of various types of steel.

For the automation of the converter process a system is being developed presently which will allow measuring the oxygen concentration in the blast, determined indirectly – based on the nature of the flame radiation – the bath carbon content and measure the converter-lining temperature.

Eventually a machine will be constructed which will regulate the converting process according to a set of automatically measured parameters (such as composition and temperature of the metal, blast, exhaust gases etc).

Electric steel furnaces will, in the near future, be equipped with the following control equipment: control of metal, slag, and furnace-lining temperature, control of furnace-heat losses, periodic analysis of chemical composition of the metal, regulators for lowering the electrodes, and control of oxygen input based on metal temperature. Computing and other control devices should also be introduced for controlling the electrical process, computing addition of materials, and controlling the heating regime.

Finally, after 1965, the complex mechanization and automation of all basic and auxiliary technological processes and operations should be completed. Continuous control of smelting would be based on the composition and temperature of the metal and slag and on data logging and control computers.

In the rolling shops, the processes of charging metal into the heating furnaces and removal of metal in accordance with the stand's rate of production should be automated in the near future. The firing regime in the furnace would be automated based on feedback about the condition of the metal in the rolling process. At present such an installation is being developed for one of the sheet rolling stands.

In the reversible blooming mills the following should be automated in the next few years: the pressure-applying mechanisms, main drives, drives on the basic mechanisms of the blooming-mill roll stand, and the metal-cutting process.

In the continuous sheeting mills, in addition to the automation of the pressure-applying mechanisms and main drives, the automatic regulation of sheet thickness and width during the rolling process is a necessity.

On continuous cold sheeting mills a system of automatic thickness regulation across the sheet and the stretching of the sheet between roll stands and before the wind-up must be automated.

In the shape mills, systems for automatically regulating the size of the kink and the metal profile dimensions between the roll-stands must be introduced.

In the pipe-rolling mills the operation of all components on the broaching stands, automatic stands and gauging stands must be automated.

Particular attention should be paid, at all rolling mills, to the complex mechanization and automation

of quality-control processes, sorting, stamping and finished-product packaging. This, because these operations are handled manually and tie up a large number of workers.

The development and mass production of the following items ought to be speeded up: quick-acting noncontacting metal-position indicators, indicators of geometric shape dimensions, temperature of flowing metal and also specialized computing devices and standard components for them. Moreover, special control machines should be developed which would coordinate the operation of a complex of mechanisms and control loops on the rolling process as a whole.

There should be considerable growth in ferrous metallurgy of mechanization based on television. This tool should be introduced primarily in situations where there is wide mechanization but dispersion as to location (electric systems and substations, water, heat and gas-supply stations, and also railway systems at the metallurgical plants). Another application would be situations where working conditions are straining.

Together with process automation television should be introduced in the continuous conveying systems at the beneficiation and agglomeration plants, coke and chemical plants, electric power stations, mine pits and underground mines.

In order to increase the handling capacity of the railways and to ensure safety during transfer and, further, to free for other duties a large number of switchmen and servicemen, the operation of switches and signals must be centralized, switches must be made operable from locomotive cabins, and the right-of-way signal system should be automated.

Particularly effective are such measures when they are introduced in conjunction with centralization of controls of the service equipment at the iron mines (e.g., water drainage, ventilation dampers, main ventilation equipment, and vertical and skip hoists). Centralized control of haulage alone will increase labor productivity and reduce the number of electric haulage trains by 25%.

The use of control rooms in the basic metallurgical-plant shops should grow significantly. Control rooms in these shops will be equipped with generators of information about the significant production-process parameters, operating indices, and also means of communication, television and teletype. It is planned to place the automatic operating-data logging equipment in these control rooms.

It is also imperative to improve the existing all-plant control rooms (dispatching stations). The latter are, in most cases, equipped with communication equipment only. At such control points should be located the record of the control indices of the plant's main shops and also of the indices of plant utilities which serve the processes, such as energy, transport etc.

Introduction of the above enumerated measures in the field of complex mechanization and automation of the processes and also the use of television and remote control will enable fulfilling the decisions of the Twenty-first Congress of the USSR Communist Party and will further enhance growth of labor productivity and the rise of the technological level in ferrous metallurgy.

BRIQUETTING OF IRON ORES

B. M. Ravich

Moscow Mining Institute

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Further large scale growth of ferrous metallurgy is dependent not only on an acceleration of growth of the iron-ore base, but also on developing rational methods for preparing the ores for smelting. In 1965, 150-160 million tons of run-of-the-mine ore will be mined. During the next 15 years the annual ore production will reach 250-300 million tons.

By the same date fines, which cannot be used directly in the smelting process, will account for 50% of the ore mined, and this in the production of both high and low-grade ores. In addition, all low-grade ores will have to be beneficiated; this also means grinding. Accordingly, the better part of the ores mined will have to be subjected to agglomeration.

Apart from sintering and pelletizing, briquetting may also be used for this purpose.

The essence of a briquetting-process flow sheet is shown in Figure 1. In some cases the function of binders is fulfilled by fluxes; sometimes strengthening of the briquettes is not needed (e.g., in cases where pitch, petroleum bitumen, etc., is used in the role of a binder).

At present the interest in briquetting is growing more and more in many countries. In our opinion, this is explainable by the fact that in a series of foreign countries [German Democratic Republic, Federated German Republic (FGR), USA, England and others] new, high-capacity, and very economical roller presses have been put into use. The latter are able to supply any metallurgical concern with all the necessary agglomerated raw material of required dimensions, form and weight; and this with a comparatively low energy consumption and machine bulk.

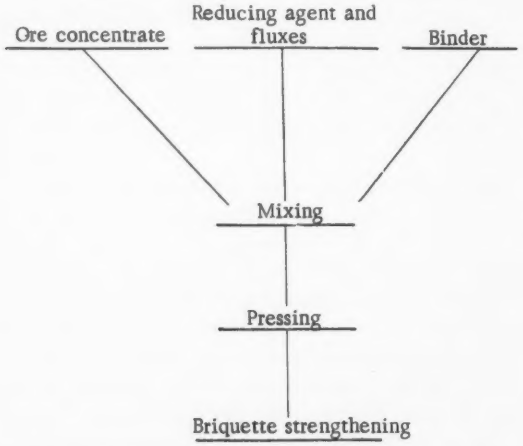

Fig. 1. Principal scheme of iron-ore briquetting: 1) ore concentrate, 2) reducing agent and fluxes, 3) binder, 4) mixing, 5) pressing, 6) briquette strengthening.

Of considerable interest is the work conducted in FGR on briquetting of limonites. Limonites from the Laubach Deposit were widely investigated. These consist of 40% of soft, weathered rock with a high moisture content. The chemical composition of the ore is as follows (in %).

Fe	SiO_2	Al_2O_3	Mn	CaO
35—39	12—15	7—8	4—6	1—3

Because of their mechanical properties and high fines content (60% minus 12 mm) these ores are not suitable for use in metallurgical furnaces without prior agglomeration. At present there exists in the FGR an experimental briquetting installation. The most essential portion of this installation is the band-vacuum press, which externally appears similar to a doubled screw auger (Fig. 2). The press consists of two augers and a vacuum chamber which is positioned between them. The first auger serves as a mixer and precompressor and the second as a forming device.

The over-all length of the press cylinder is 2.3 m and the diameter is 500 mm. The exit die on this press has 14 openings. The electric drive has a power of 120 kw, and turns at 1450 revolutions per minute. Machine capacity is up to 10 tons of briquettes per hour. The following were used as binders: cement, sulfite, liquor, coke fines, white and gray slaked lime, unslaked lime etc. The briquettes were slowly calcined at 1200° for one hour. During this treatment the strength of the briquettes increased.

Testing of various ores on a semi-works installation has shown that the problem of briquetting limonites has been solved technically. However, because of the expensive thermal treatment required this process can be used only in regions where a cheap source of fuel is available.

Similar installations, though somewhat different in arrangement, exist in England and Canada.

Based on tests in the FGR it was established that fine grained and dustlike ores when mixed with soft brown coal and slaked lime could be briquetted without a special binder when pressed under high pressures. Moreover, the ore was suitable for being pressed in plunger-type and cyclic presses in spite of its high hardness and abrasiveness. Heat stability and mechanical properties of the briquettes satisfied the requirements of materials used for smelting in low-shaft furnaces. A better heat resistance at high temperatures was obtained when low-grade ore was briquetted with a high content of silica. This was explained on the basis that the high silica content required a larger lime addition in order to obtain the necessary slag basicity.

At the Chemical Institute of the Bulgarian Academy of Sciences, methods were investigated to produce "iron-coke" and ore-coal briquettes. These two methods were also tested and compared with one another there. Comparison of iron-coke with ore-coal briquettes showed that considerably better results were obtained with ore-coal briquettes prepared in such a way that the amount of combustible present in the mix did not exceed the amount necessary for reduction of the ore. The best combustible for briquetting was coke or a well-coking coal. Careful mixing, grinding in a common mixture and briquetting increased the reduction rate. This enabled obtaining briquettes of satisfactory quality even from mixtures of anthracites and poorly reducible magnetites. Other mixtures were also subjected to tests.

Research, experimental and plant-scale testwork on ore briquetting was also done in Poland, Rumania, Japan, France, USA , the Chinese People's Republic and other countries. Their results showed that briquetting can not only agglomerate ores but can also utilize types of coal which were previously thought unsuitable for metallurgical uses (noncoking hard coals, brown coals etc). Of greatest interest are investigations conducted in the German People's Republic at the "Maxhuette" plant.

The ore subjected to briquetting contained 23-33% iron. The charge consisted of 50% ore, 40% slaked lime and 10% coke breeze. Pressing was on a roller press at low pressures (up to 200 kg/cm^2). Briquettes were treated with exhaust gas from blast-furnace blast-heating stoves, at a temperature of 120° for a period of 0.5-2 hours. In this treatment $Ca(OH)_2$ was transformed into $CaCO_3$; this served to strengthen the briquettes. Smelting of the briquettes in low-shaft furnaces gave favorable results; productivity increased by 15%, coke consumption dropped by 16% as compared to performance on a conventional charge. In Alabama (USA) a plant which produces iron briquettes is in operation. Low-grade hematite ores (Fe up to 35%, SiO_2 up to 15%, CaO up to 16.5% etc.) are briquetted with portland cement on roller-type presses made by the firm "Comarek-Graves". In the USA 220 thousand tons of ore briquettes are being smelted annually.

Briquettes may also be successfully used in the open hearth process. They give a better performance than agglomerate because of their higher bulk density. This is confirmed in part by the work conducted under industrial process conditions by the Ukrainian Institute of Metals at the Dzerzhinskii plant.

For example the use of briquettes has reduced the duration of a heat of rail steel by one hour and three minutes as compared to conventional charges, while the use of agglomerate reduces the heat duration by only 49 minutes. In addition it was possible to raise slag basicity, to raise furnace productivity by 6-7%, to reduce the total quantity of FeO in slags in the initial period of the heat and to increase it at the end of this period, etc. It has been shown that it is possible to use ore-lime briquettes in finishing the heats, instead of using ore and lime.

Extensive investigations conducted at the Moscow Mining Institute gave positive results when friable high-grade ores of finely ground concentrates were used, as for example, the KMA quartzites (iron content,

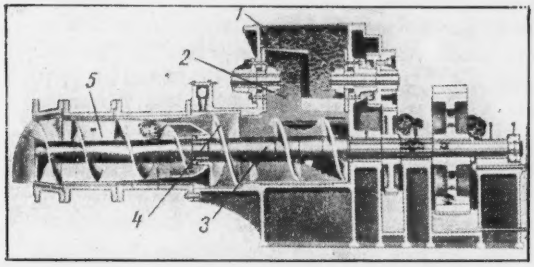

Fig. 2. Band-vacuum press: 1) charge, 2) pre-pressing chamber, 3) feeder, 4) vacuum chamber, 5) pressing portion.

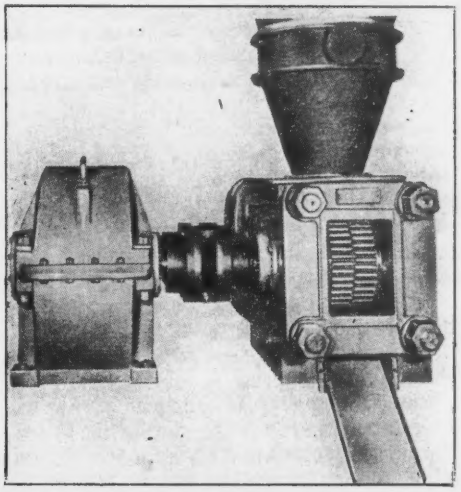

Fig. 3. Comarek-Graves Press.

up to 60%) and the Kimkan ores (iron content, up to 65%).

The fluxed briquettes were strengthened by steaming in industrial autoclaves at a pressure of 7 atm and a temperature of 174°, or by carbonization. During this treatment the briquettes obtained high mechanical strength. Carbonization is the better method for strengthening briquettes (those made from concentrates containing a limited amount of SiO_2).

Investigations at the Moscow Mining Institute of the production of fluxed ore-coal briquettes made from the Lisakovsk-deposit limonites and concentrates made from this deposit's ores are of interest. The composition of the ore and the concentrate is as follows, %:

	Fe	SiO_2	Al_2O_3	CaO	MgO
Ore	48-64.8	23-38	0.5-1.5	3.8	1.2
Concentrate	73.5-89.4	4.4-14	—	—	—

Coke breeze, nonclinkering coal, coking coals from the eastern deposits, and coke made from the latter coals were all used as reducing agents. The investigations were conducted according to three schemes: 1) the charge consisting of ore, brown-coal or hard-coal coke, and slaked lime was pressed and the briquettes thus obtained were strengthened by means of steaming or carbonization, 2) the coal-ore charge containing a binder (pitch, bitumen, etc.) was pressed at a low pressure, 3) the coal-ore charge was pressed without a binder at a high pressure.

As a result of this work it was established that sufficiently strong ore-coal briquettes may be made from the Lisakovsk ore. Good results are also obtainable when briquetting concentrates made from this ore.

However introduction of briquetting is made more difficult by some inadequacies. Roller-type presses for the manufacture of briquettes by the domestic industry do not as yet have a sufficiently large capacity in order to compete with other methods of ore agglomeration.

It should be noted that, of late, presses have been manufactured in foreign countries which can satisfy the capacity requirements of metallurgists. A series of firms in the FGR and in England are manufacturing roller-type presses which have a capacity of 50-70 tons/hr of coal briquettes or 75-100 tons/hr of ore briquettes. Since 1958, the American firm Comarek-Graves has been manufacturing roller-type presses which compact the charge prior to extrusion and which are designed to give a unit pressure of 900 kg/cm^2 (Fig. 3). Use of such presses may enable production of briquettes without binder addition. Improvements in the strengthening stage or elimination of the strengthening process altogether should also be possible. This will tend to simplify significantly the briquetting of iron ores.

Experimental and plant-scale work on briquetting should continue. There is a possibility that in the future briquettes may become a blast-furnace raw material equal in importance to sinter and pellets.

* * *

FLUIDIZED-BED LIMESTONE CALCINATION

V. M. Dementiev, M. M. Kotrovskii, and Yu. P. Nekhlebaev

Makeev Metallurgical Plant

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Inclusion of lime in the sintering charge brings about a substantial increase in the productivity of sintering machines. Consequently, the ability to produce large quantities of calcined lime assumes considerable importance. At the Makeev Agglomeration Plant limestone is calcined in two rotary machines of the OPR-type* which, however, are not able to ensure a supply of lime for the plant. In spite of the relatively large charge capacity per 1 m^2 of calcining area the unit has a series of fundamental deficiencies.

The most important technological deficiency of the OPR machine is the fact that the process temperature cannot be controlled. This requires operating at high temperatures (in order to sustain the process) which in turn causes the binding properties of lime to deteriorate. As a result the role of lime as a process intensifier is decreased. In this way the low effectiveness of using lime from OPR machines may be explained; in our plant the addition of 1% CaO raised the capacity of the sintering strands only by 1.5%, whereas lime from shaft furnaces raises the capacity by 4-5%.

According to our estimation, the most promising method of lime production is calcination of limestone in a fluidized bed. An experimental unit for calcining

*Concerning the OPR-type machine, see Stal, No. 3 (1958).

limestone in the fluidized bed has been built and equipped at the Makeev Metallurgical Plant.

The furnace shaft, 250 mm in diameter and 875 mm high, was made of firebrick; wall thickness was 125 mm. From the outside the shaft was lined with metal plate. Limestone was charged to a bin and from there, through a screw feeder, to the furnace. Calcined lime was discharged through an outlet pipe to a finished product bin. Bed height was determined by the distance between the bottom rim of the discharge pipe and the grate. In the unit this height was about 400 mm. For removal of combustion products a VVD-No. 8 ventilator was installed. Coke-oven gas was introduced from the gas duct through a burner equipped with six inclined openings, 6 mm in diameter. It was initially proposed to suck in the air from the atmosphere by means of an exhaust fan through a grate. The grate was made from sheet steel, 8 mm thick, with 3 mm diameter holes; void area in the grate was 6%. In order to observe the fluidized bed a sight glass was installed at the top of the furnace.

In the process of developing the unit a few weaknesses in design became apparent. Vacuum produced by the exhaust fan proved inadequate in sucking in a sufficient amount of atmospheric air. Accordingly, compressed air at a pressure of 5 atm was supplied to the furnace. Gas supply also proved inadequate due to insufficient pressure in the supply lines. In order to supply the necessary quantity of gas an ejector was installed in which gas was aspirated by compressed air. In the side of the burner cap additional holes were drilled.

The screw feeder did not prove satisfactory in supplying limestone to the furnace. When the screw diameter was 32 mm and limestone particle size was 3-5 mm the feeder acted as a mill. Accordingly, the screw feeder had to be dispensed with and replaced with a table feeder. This required changing the location of furnace feeding.

As a result of positive pressure in the furnace there was danger that combustion products might be blown out through the inlet pipe. In order to eliminate such a possibility an air line was installed at the mouth of this pipe.

An exhaust pipe was installed for combustion-products removal. The exhaust fan was only used for creating a vacuum in the furnace during periods where the "fluidized bed" was being observed.

The arrangements of the experimental unit after these modifications is shown in the diagram.

In the tests limestone of following chemical composition (in percent) was calcined,%:

$CaCO_3$	$MgCO_3$	SiO_2	Others
83	6	4.2	6.8

Limestone bulk density was 1500 kg/m^3; apparent specific gravity was 2500 kg/m^3. Limestone particle size was 3-5 mm. The limestone was calcined with coke-oven gas with a heating value of 4347 kcal/nm^3. and a specific gravity of 0.446 kg/nm^3.

During the calcining process the gas and air consumption were constant (36 nm^3/hr of coke-oven gas and 180 nm^3/hr of air).

Based on such consumption the actual or "hot" combustion-products velocity in the furnace shaft was 4.65 m/sec based on the total cross-sectional area.

The degree of fluidized-bed "forcing", as determined by the ratio of actual gas velocity to the gas velocity necessary for bed fluidization, was in our experiments equal to 2. For this the velocity necessary for bed fluidization was determined by the approximate formula obtained for limestone:

$$w_0 = 0.03 \cdot t^{0.5} \cdot d^{0.65},$$

where

w_0 - velocity necessary for bed fluidization m/sec;

t - bed temperature °C;

d - limestone, particle size, mm.

At a 3-5 mm fraction and an average bed temperature of 930° the velocity for bed fluidization was equal to 2.25 m/sec.

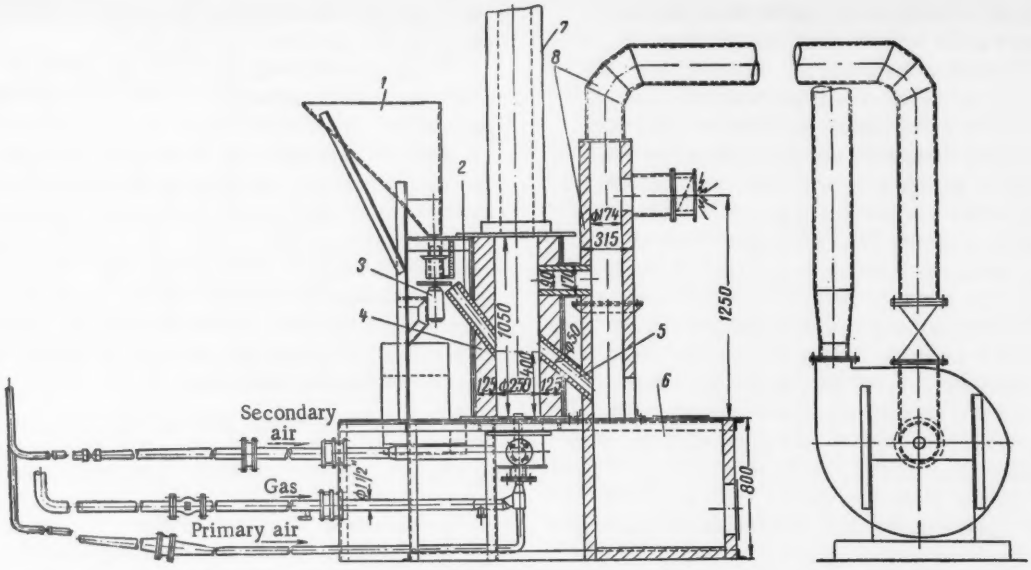
In the course of the investigations it was shown that the gas streams are channelled in the fluidized bed largely in parallel, and this in spite of the intense mixing of the particles. Because of such aerodynamic conditions the gas and air do not mix sufficiently well. In the experimental unit a better mixing between gas and air was obtained by directing the gas-air streams from the burner cap at an angle of 45 and 90° to the direction of air flow. In addition the installation of the ejector brought about an increase in the kinetic energy of the gas-air stream and consequently an increase in the turbulence of flow in the furnace. Thermotechnical analysis of the process indicated that for satisfactory combustion of fuel in the bed one of the following methods may be applied:

1. "Bind" the fuel to the particles in order to ensure in this way that the latter would be distributed throughout the bed. Such a method is used in some foreign countries, where oil is forced in through side jets in the furnace.

2. Introduce an aforetime prepared gas-air mixture into the bed, i.e., each opening in the grate should become an outlet of a flameless burner.

3. Introduce combustion products into the furnace. In this case the design of the furnace bottom is complicated and the benefits derived from high-temperature heat release during combustion are reduced. This, because introduction into the furnace of combustion products from high-calorific-value gases will lead to weakening of the furnace bottom.

In practice numerous ways of introducing fuel into the bed are possible and these are more or less related to the optimum variants discussed above (e.g., introduction of partially prepared mixture, introduction of semi-combusted gas, etc).



An apparatus for calcining limestone in a fluidized bed; 1) raw-limestone bin, 2)feed pipe, 3) feeder, 4) furnace, 5) discharge pipe, 6) calcined-lime bin, 7) exhaust pipe, 8) exhaust-handling system.

However judging by combustion standards such methods are inferior to those described above.

A very characteristic property of a fluidized bed is a practically uniform temperature at all points. This is explained by an intense mixing of particles of material being calcined. At the same time it should be noted that when the feed rate changes there is a rapid change in temperature. Because of the rapidity of these temperature changes and difficulty of manual control, bed temperature fluctuated through a fairly wide range (± 50° at an average of 930°). Such a rapidity of temperature change easily allows automation of the calcining process.

The thermal efficiency of the apparatus was calculated from heat balances. It was on the average 35%. The degree of calcination of the limestone was only up to 65%.

The low degree of calcination might perhaps be explained by the fact that the inlet and outlet pipes were located close to each other, which may have led to short circuiting of particles from the inlet to the outlet. This interpretation is supported by the presence in the calcined material of semi-calcined, noncalcined and even unheated particles. In addition lowering the bed temperature to 870° during a few periods had a negative effect on the quality of the calcine.

Under production-scale conditions, operation in multistage furnaces, and automation of the calcining process the degree of calcination will be on the average 98-99%.

In the course of experimentation at a medium forcing rate – equal to 2 – the capacity of the unit fluctuated between 70 and 140 kg/hr of limestone. Accordingly the specific capacity was 1320-2640 kg/hr·m^2. The average specific capacity during the experimental period was 1850 kg/hr·m^2.

The experimental results allow calculation in advance of the capacity of a production-scale furnace for fluidized-bed calcining of limestone.

According to a theoretical analysis of the process, the specific capacity under conditions different from the test conditions may be calculated by means of the following relationship

$$\frac{G_x}{G_o} \simeq \frac{m_x}{m_o} \cdot \frac{\eta_x}{\eta_o} \cdot \frac{\beta_o}{\beta_x} \cdot \left(\frac{d_x}{d_o}\right)^{0.65}$$

where:

G_o, m_o, η_o, β_o, d_o are respectively, the specific capacity, "degree of forcing," thermal efficiency of the process, the degree of calcination, and particle size, at experimental conditions. Same symbols with subscripts "x" denote the corresponding properties at production-scale conditions.

When going from test conditions to production scale conditions the following must be taken into account:

1. the "degree of forcing" may be raised to 3;
2. the thermal efficiency of a production scale unit – which should be a multistage one – should be about 75%;
3. because a production scale unit will be operating in an agglomerating plant the particle size will be 3-12 mm;

4. the degree of calcination will be 95%.

The specific capacity of a production unit will under such conditions be 5-7 ton/ m^2·hr of limestone and will depend on the degree of bed "forcing".

Anticipating that, in general practice, the fluidized-bed limestone reactors will be 16-18 m in diameter the capacity of a single installation for limestone calcinating will be a few thousand tons of finished lime per day.

Based on the experiments, the following conclusions may be drawn:

1. Calcination of limestone in a fluidized bed is an efficient process. Under conditions existing in agglomeration plants the productivity of such units will be 5-7 ton/ m^2·hr.

2. The speed of the process calls for its automation. This will permit maintaining a constant calcining temperature and obtain calcined lime of excellent quality.

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COMPLEX UTILIZATION OF IRON ORES

I.S. Shapiro

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At present the term "complex utilization of raw materials" is met with frequently in the technical and economic literature. This term means a complete recovery of all raw-material components including the tailings formed during its processing. A very striking example of a complex raw-material utilization is the contemporary processing of coal at a coke-chemical plant. The gas that is formed there was at one time considered a waste and was let out into the atmosphere; the only purpose of a dry-distillation process was to produce coke. At present the recovery of gas has been added; this gas is a raw material for the production of most valuable chemical products. The tar, benzene and ammonia that can be obtained from this gas are used for the production of nitrogen-containing fertilizers, plastic masses, explosives, naphthalene, rubber, dyes, drugs, perfumes, caprone fiber and many other products.

After a chemical treatment the coke-oven gas is sent to the open-hearth, preheating and other furnaces and the coke serves, as in the past, as a process fuel in the blast-furnace process.

In a complex utilization of the raw material, its cost is distributed over a number of products. This fact reduces the cost of the finished product, reduces capital investment per unit of plant capacity, and also broadens the raw-material base of some products. The more products produced from the coke-oven gases the cheaper is the coke and the lower is the capital investment charged to a unit of capacity of a coke oven battery.

Presently complex raw-material utilization is practiced in the petroleum industry, in the processing of wood, nonferrous metal ores and a host of branches of the fish industry.

Nonferrous metal ores are in most cases polymetallic ores. Thus the Ural copper ores contain besides copper also zinc, gold, silver, sulfur, iron, arsenic, selenium and tellurium. The Altai polymetallic ores contain lead, zinc, copper, gold, silver, sulfur and cadmium.

The insignificant percentage in such ores of nonferrous and rare metals or widely disseminated elements and the resulting large consumption of ore in order to obtain a ton of metal calls for a complex utilization of the polymetalltic ore which is as complete as possible. In addition some metals can be concentrated only in a complex flow sheet because they accumulate in the tailings from polymetallic-ore processing.

The ferrous metallurgy is treating ores which contain 25-65% iron. These ores, similar to all others, contain many minerals. In them there are nonferrous, rare and disseminated metals and also various nonmetallic elements, which are of importance to a diverse number of branches of the industry and the national economy.

Iron ores are found to contain the following elements which are vital for the national economy: titanium, manganese, copper, zinc, nickel, cobalt, chromium, arsenic, vanadium, tungsten, molybdenum, gold, silver, platinum, selenium, tellurium, fluorine, barium, germanium, magnesium, calcium, aluminum, boron, sulfur and phosphorus. As early as 1937 one of the rare-metal-industry workers, the engineer Yu.A. Bogomolov wrote ". . .every year our ferrous metallurgy is processing, without suspecting it, hundreds of tons of particularly valuable and expensive rare and disseminated metals."

Below are analyzed the possibilities and practice of the complex utilization of some industrial types of iron ores.

Magnetites frequently contain, in addition to iron, copper, zinc and cobalt. It is well known that the old Ural roofing iron exhibited rust resistance which was not due to a particular method of manufacture but to the presence in the metal of copper and sometimes nickel and cobalt. The same copper-containing magnetites of the Northern Urals are now used for iron production at the Serov Works and for the production of copper. A portion of the Visokogorsk and Goroblagodatsk ores in the Central Urals contain copper and cobalt in industrially attractive quantities. Cobalt is also found in industrially attractive quantities in a part of the Magnitogorsk ore. Magnetite ores from Gornaya Shoria and Khakassia, which form the basis of operation of the Kuznetskii Metallurgical Combine (now it is common to call these ores Altai-Sayansk ores), contain, apart from iron, also copper and cobalt; some of these ores also contain appreciable quantities of zinc and sulfur.

During the preparation for smelting the Altai-Sayansk ores are subjected to a dry and a wet magnetic separation. Experimental work has shown that by subjecting the tailings from the magnetic separation to flotation, a cobalt, zinc and copper concentrate may be obtained. Sulfur which is suitable for the production of sulfuric acid is also obtained. For a satisfactory nonferrous metals recovery the Altai-Sayansk ores must be ground finer than they are at present for the beneficiation and production of an iron concentrate.

Hematites frequently contain rare-earth elements which are extremely important as alloying agents for steel; they are also used in glass manufacture, in the nuclear technology and as catalysts.

Complex utilization of the ore portion of magnetite and hematite ores, which form by far the greatest part of the ores mined in the USSR, is hardly practiced at all.

Limonite ores of sedimentary origin contain, in comparison with other iron ores, an appreciably large amount of phosphorus and arsenic, some of them contain vanadium. From the Lorraine limonites (oolitic iron ores) which are processed by the ferrous metallurgy of France, the German Federal Republic, Belgium and Luxemburg, phosphorus is recovered in the process of blowing pig-iron into the converter. At the Azovstal' Works there are tilting-type open-hearth furnaces which treat pig-iron made from the Kerch ores which contain about 2% phosphorus. In the future it is proposed to recover phosphorus from the Lisakovsk Deposit limonites. Phosphorus-containing slag when ground into a fine powder is a valuable fertilizer.

Chromium and nickel-containing limonites are also valuable raw materials. Yet the objective of their processing is not always the production of a number of products, i.e., a complex utilization. Chromium and nickel are elements which are added to steel in order to improve its quality. Accordingly a naturally alloyed chromium-nickel-cobalt ore is processed at the Orsk-Khalilovsk Metallurgical Combine to produce chrome-nickel steels, whereby the nickel contained in the ore is transferred into the steel. Regrettably, during the metallurgical treatment the chromium contained in the ore is virtually completely transferred into the slag. On the other hand, a complex utilization of these chrome-nickel ores or similar complex ores is possible with the production from them of several intermediate products. Accordingly when the chromium-containing brown ores and high-alumina ores of the Northern Urals were investigated the following scheme was proposed for their complex treatment: Production of a low-alloy chromium-nickel steel, and recovery from the converter slag of chromium for the production of ferrochrome, chromosilicon and sodium bichromate. It is proposed to process the high alumina slags from blast-furnace smelting into cement.

Presently titanomagnetite ores are subjected to complex utilization in the Soviet Union. These ores contain vanadium in addition to iron and titanium. Titanomagnetite ores from the Kusinsk Deposit in the Southern Urals are separated into two fractions, one consisting largely of ilmenite and containing titanium and the other a magnetite containing iron and the vanadium locked into it. The titanium concentrate serves as a raw material for the production of titanium metal in the chemical industry and also for the production of white pigment. The magnetite concentrate is utilized in the ferrous metallurgy.

At present a large mining and concentrating combine is under construction at the Kachkanarsk Deposit of titanomagnetite ores (Central Urals). Iron and vanadium will be concentrated from these ores. The Kachkanarsk ores do not contain much titanium and therefore the latter will not be recovered as a distinct product. Platinum, which is also contained in the ore to an insignificant degree, will similarly not be recovered. However the production from the Kachkanarsk Deposit will have interesting features, namely: the overburden rock and dry-magnetic-separation tailings will be utilized as intermediate products. The Kachkanarsk ores are imbedded in rock from which valuable construction materials may be obtained. The latter are rubble-stone, gravel for making high strength concrete, and sandstone. These materials will be used by the construction organizations in the Urals.

During the current Seven-year Plan large deposits of low-grade iron ores will be brought into production. Specific consumption of raw iron ore per ton of beneficiated ore will increase from 1.29 tons in 1959 to 1.54 tons in 1965. The reject from the beneficiation will increase substantially. Promyshlennaya-Ekonomicheskaya Gazeta published a proposal to process the tailings from the beneficiation of Krivoi-Rog quartzites in order to obtain refractory and construction mate-

rials. The authors of this proposal calculate that it will be possible in 1965 to produce from the Krivoi-Rog-Mining-and-Concentrating Plant rejects sufficient silica brick to satisfy the needs of the whole country for this material.

The ferrous metallurgy also consumes, apart from iron ore, huge quantities of rock: limestone, dolomite, fluorspar and bauxite. Together with the waste rock contained in the iron ore they constitute yearly tens of millions of tons of slag which are only partially used for the manufacture of construction materials.

The ferrous metallurgy can promote complex utilization of raw materials in other branches of the industry. As is well known a by-product of the sulfuric acid industry are the pyrite cinders containing over 50% iron. Presently, only a very small part of these rejects is utilized by the ferrous metallurgy.

The remarkable Soviet geologist and geochemist A. E. Fersman, who was a keen supporter of complex utilization and composite production, wrote in 1932 as follows: ". . .the production process has been well designed if not a gram is lost from the mass of ore taken out of the mine, if there is not a gram of tailings, if there is no waste to the air and if nothing is lost, dissolved in the waters." Realization of the proposals to utilize overburden rock and concentration tailings, and the increase in the utilization of slags, will bring the processing of iron ores closer to this ideal scheme.

AN EXPERIMENT IN BLOWING THE METAL IN AN ACID OPEN-HEARTH FURNACE WITH COMPRESSED AIR

V. A. Kudrin, Yu. M. Nechkin, E. I. Tyurin, and E. V. Abrosimov

Moscow Steel Institute

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Experience at factories at home and abroad has shown that blowing the metal in the basic open-hearth furnace with oxygen or air considerably raises the production capacity of plants.

Thus, the use of the oxygen for blowing the bath in furnaces at the "Serp i Molot" factory increased their production capacity by 5-10%, about 5 m^3 of oxygen being used per ton of steel. If oxygen is not available it may be successfully replaced by compressed air.

As regards oxygen-blowing in acid open-hearth furnaces, until recently similar tests had not been carried out, although in Sweden a considerable part of the acid open-hearth steel is smelted with the use of oxygen for blowing the liquid metal.

To develop the special technique for melting steel in the acid furnace with blowing of the bath, a series of melts was performed at one of the Urals factories with the use of compressed air.

The tests were carried out in 85-ton acid open-hearth furnaces with hearth areas of 27-28 m^2 and bath depths of 860 mm; blast-furnace gas and oil were used as fuel; the chief type of steel was ShKh 15 in which the process takes place with limitation of the silicon reversal. The length of the boil period was 2-3 hours. In blowing, iron tubes an inch in diameter and four to six meters long were used. The compressed air pressure in the system was 4-6 atm, and the consumption approximately 700 m^3/hr (reckoned at NTP).

The change in metal and slag composition during one of the experimental melts is shown in the figure.

Analysis of experimental melt materials showed that during the blow the rate of carbon removal is considerably increased: in individual periods it reached 0.75% C/hr (as compared with 0.20-0.38% C/hr for ordinary melts). Delay in raising the metal temperature from the decarburization process was not observed. It was quite the reverse — during blowing the rate of temperature increase was markedly raised — up to 2° per minute (more than twice the rate in ordinary melts); as a result of this the metal temperature* rose by 50-60° C in a short space of time.

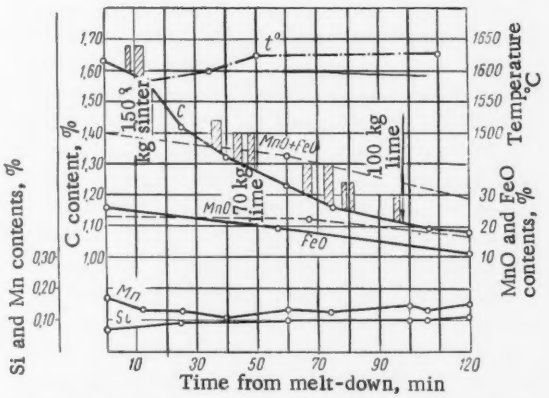

Diagram for melt 6001 (shaded regions show the times at which air-blowing was carried out).

Heat calculations carried out for the case of blowing the bath with air indicate that the heat used up in heating the air is over-compensated for by the heat given off as a result of oxidation of impurities in the metal, and these reactions proceed preferentially in air-blowing by the consumption of the oxygen in the open-hearth furnace atmosphere. The improvement in the conditions for heat adsorption in the vigorous turbulence also promotes the more rapid heating of the metal in the air-blow.

In the test carried out the metal temperature rose so rapidly during blowing that it became necessary to cut off the supply of oil to the furnace.

Analysis of the change of slag composition in the course of a melt indicated that the ferrous oxide content, and similarly FeO + MnO, not only does not increase during the blow, it is even somewhat reduced. The concentration of silicon and the quality of the metal were not lowered by a blowing (see the table).

Macro-examination of the finished rolled product was in all instances quite satisfactory. The nitrogen

*Measured by a tungsten-molybdenum immersion thermocouple.

Quality of Metal (according to GOST – All-Union State Standard – 801-47)

Detail	Experimental melt number					Average for two months (total production)
	5784	5921	6001	6018	7955	
Average sulfide index	2.41	2.60	2.80	2.54	2.40	2.58
Average oxide index	2.12	2.50	2.30	2.12	2.10	2.33
Average spherical inclusion index	2.21	2.55	2.35	2.42	2.10	2.41

content of the metal (%), as can be seen in the figures given below, lies in the range normally observed in the acid process:†

Melt number	5784	5921	7955	8911	8933	3008
Nitrogen content %	0.0033	0.0027	0.0016	0.0011	0.0015	0.0011

In this way it has been established that blowing the acid open-hearth bath with air speeds up decarburization, markedly raises the metal temperature in the blowing period and shortens the boil period without adversely affecting the quality of the metal. Blowing the bath makes it possible to do without scarce iron ore free from phosphorus and sulfur and to avoid the contamination of the steel with alumina which is then found.

Blowing the bath with air, because of the rapid heating of the metal, considerably shortens the period while the bath is passive after melt-down of the charge before the beginning of the active boil.

† The nitrogen content of the metal was determined by the ammonia-evolution method in the laboratory of the Moscow Steel Institute.

* * *

ON THE PROBLEM OF SMELTING TRANSFORMER STEEL

S. M. Gnuchev, D. G. Zhukov, N. V. Keis,
Z. V. Klochkova, P. M. Danilov, and K.N. Konovalov

Central Research Institute for Ferrous Metallurgy, Chelyabinsk Metallurgical Factory, Kuznetsk Metallurgical Combine
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The electrical industry makes high requirements as to the magnetic and electrical characteristics of transformer steel. At the moment metallurgists have not completely fulfilled these requirements. The level of the standard characteristics, as is well known, is determined by the whole complex process of production, starting from the smelting of the metal. Results have been collected below (Fig. 1) from a study of the particular details of the smelting technique used for transformer steel in different factories.

The feature distinguishing the technique adopted at the Dneprospetsstal' factory is that, at melt-down of the charge, 0.30-0.40% C and a comparatively high sulfur content (0.030-0.035%) are obtained. Carbon is oxidized by ore to 0.10-0.15%, and then by gaseous oxygen at a pressure of 6-8 atm down to 0.02%. The duration of the reducing period depends on the sulfur obtained in the finished metal (according to the factory instructions not more than 0.005%) and in practice varies in the range 1 hr 30 min to 2 hr, being at present 1 hr 20 min to 1 hr 40 min. With the aim of obtaining low carbon and sulfur contents in the metal the process is carried out at a high temperature. The temperature of the metal before pouring from the furnace should be 1640-1660° C, and in the ladle 1620-1640° C. After pouring, the metal is processed in the ladle in a vacuum chamber. Since 1958 they have started to vacuum-treat the metal stream while pouring it from one ladle to another. The metal is cast into ingots weighing 11.5 tons.

The smelting technique set up at the Kuznetsk-Metallurgical Combine (KMK) differs considerably

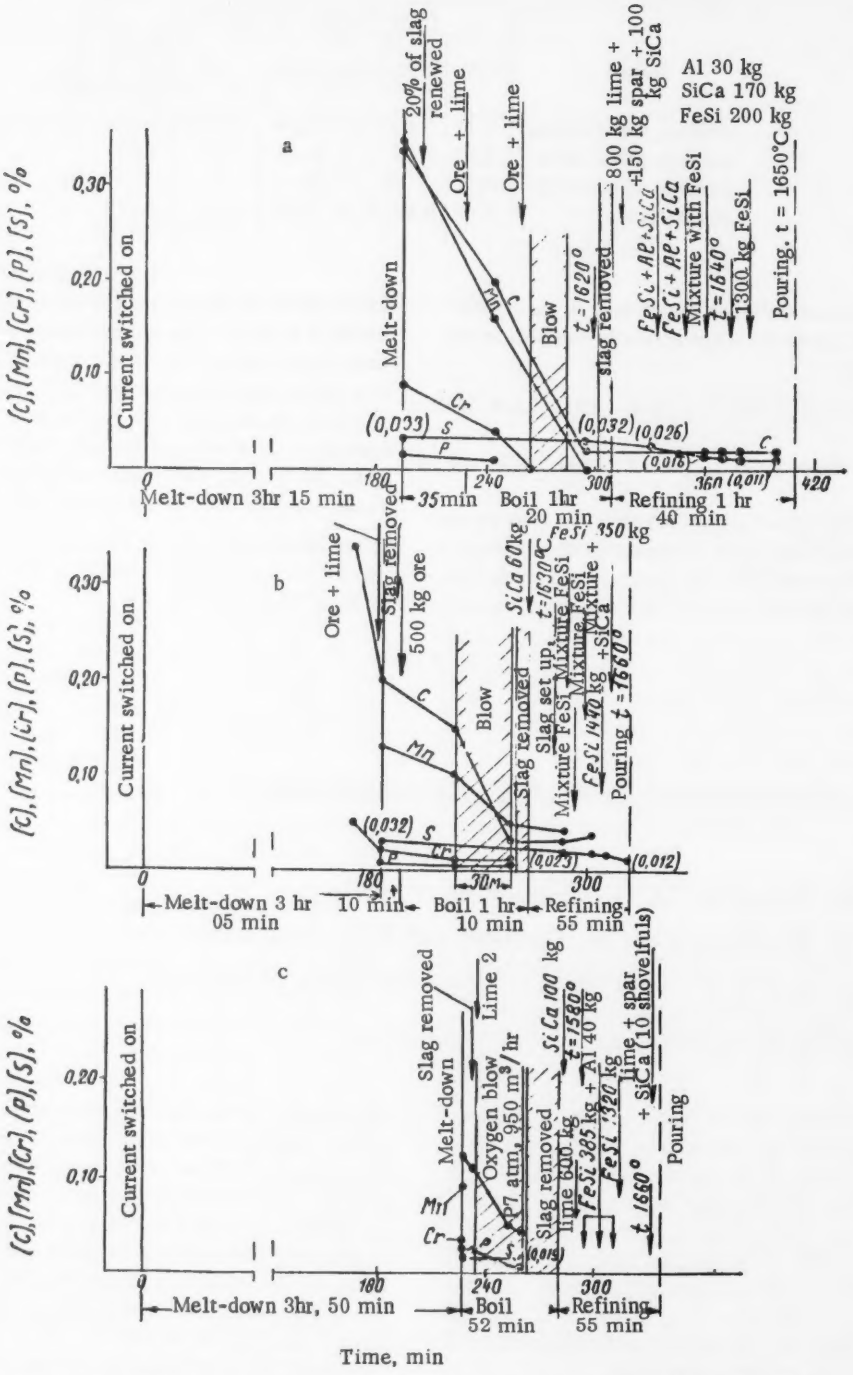

Fig. 1. Change in metal composition in the course of the melt at different factories.

Label in Figure	Factory	Charge	Duration of melt from switching on current to pouring, hr/min	Energy consumption, kw-hr/ton	Designated composition, %							
					C	Mn	P	Si	S	Cr	Ni	Cu
a	Dneprospetsstal'	Plain carbon slabs, lime	6-50	720	0.02	0.17	0.003	3.10	0.005	Trace	0.10	0.05
b	Chelyabinsk	Plain carbon scrap, ore, lime, coke	5-20	705	0.04	0.10	0.004	2.97	0.008	0.04	0.08	0.15
c	KMK	Plain carbon blooms, end croppings, scrap ore, lime	5-37	613	0.03	0.07	0.006	3.10	0.007	0.05	0.09	0.13

from that adopted at the Dneprospetsstal' factory. Good selection of the charge for chemical composition and size makes it possible to have a calculated carbon content of 0.25-0.30% and a sulfur content of 0.02-0.03%. By loading 2.5 tons of ore and 800 kg of lime (sulfur content in the lime less than 0.01%) into the furnace together with the charge, and by adding 300-400 kg of limestone at the end of melt-down, on melting-down a carbon content of 0.07-0.17% and a sulfur content of 0.018-0.025% are obtained. By the time the first sample is taken, the bath is boiling strongly. After removal of the slag from the furnace, a new lime slag is made (600-800 kg lime and 150-200 kg ore) and they set about blowing the bath.

The instructions permit up to two tons of charge to be on the banks at this time to avoid overheating the metal.

Blowing is carried out with a water-cooled and mechanically operated lance or simultaneously through two 19 mm pipes at a pressure of 6 atm; about 1000 m^3 (at NTP) of oxygen is used per hour. Blowing lasts 20-25 min. This combination of the oxidation period of the melt with the melting-down considerably eases the steelworker's task, since the amount of ore and lime necessary to carry out the boil and to remove impurities is loaded at the same time as the charge. Moreover, the early slag formation in the furnace creates favorable conditions for the removal of chromium, phosphorus and manganese. During the blowing of the bath the carbon content is reduced to 0.02-0.03%. The reducing period of the melt lasts 50-55 min.

The good organization in carrying out melting at the Kuznetsk Combine should be noted. This makes it possible to limit the number of times the chemical composition of the bath is checked to 2-4 during the course of the entire melt, whereas in the other two factories the composition of the bath is checked 8-12 times by the express-laboratory. In the combine the consumption of electric energy is less than at the Dneprospetsstal' and Chelyabinsk Metallurgical Factories, by approximately 100 kw-hr per ton. The metal is poured from the furnace through a well laid-out aperture. The metal temperature in the ladle is specified by the instructions to be 1570-1590° C.

The metal is cast as ingots weighing 7.2 tons. The melting technique for transformer steel used at the Chelyabinsk Metallurgical Factory (ChMZ) up to January 1960* provides for carrying out the oxidizing period in the same manner as at the Dneprospetsstal' factory, namely with iron ore and subsequently removing the carbon, starting from 0.10-0.15 down to 0.02-0.03% C, by blowing the bath with oxygen. Oxygen at a pressure of 11-12 atm is used for the blow. The oxygen is supplied through a single pipe 19 mm in diameter for 25-30 min. The duration of the refining period generally does not exceed one hour.

The optimum temperature of the metal in the ladle at the Chelyabinsk Metallurgical Factory is 1570-1590° C.

The relation between the rejection of the slabs because of surface defects and the temperature of the metal in the ladle is shown below:

Temperature, °C (platinum-platino-rhodium immersion thermocouple)	Number of melts	Rejects %
Up to 1565	43	1.06
1570-1590	171	0.80
above 1590	86	2.05

*Now the factory has combined the oxidation period with melting-down, 2.5 tons of iron ore and 1.0 ton of lime being introduced at the same time as the charge.

TABLE 1. Range of Oxygen Content Variation in the Bath in the Course of Melting.

Factory	No. of melts	Oxygen content, %		
		Before blowing	After blowing	Before alloying with silicon
KMK	—	0.016-0.017	0.047-0.106	0.030-0.050
ChMZ	9	0.032-0.058	0.049-0.087	0.031-0.044
Dneprospetsstal'	9	0.032-0.076	0.055-0.131	0.020-0.043

TABLE 2. Typical Duration of Melt Periods (Hours and Minutes)

Factory	Melting down	Ore boil	Blow	Refining	From melt-down to pouring	From switching on to pouring
Dneprospetsstal'	3-10	0-30	0-25	1-30	2-45	5-55
			0-30	2-00	3-15	6-25
KMK	3-30	0	0-20	0-50	1-30	5-00
			0-25	1-00		
ChMZ	3-20	0-20	0-25	0-50	2-15	5-25
		0-30	0-30	1-00		

In Table 1 is shown the range in the change of oxygen content during the course of melting transformer steel at the various factories. The greatest oxidation of the metal is found after blowing the bath in melts at the Dneprospetsstal' factory. However, with more prolonged refining and with a higher consumption of deoxidizers as compared with the consumption at the other factories, the oxygen content turns out to have more or less the same value before the alloying of the bath.

In Table 2 typical values are presented for the duration of the separate periods of melts at the three factories referred to.

It can thus be stated that important differences exist in the smelting technique used for transformer steel at the different factories.

Rejects in the first reduction at all the factories were small. At the Dneprospetsstal' factory, rejects for scabs and seams periodically arose; this is connected with the difficulty of casting 11.5-ton ingots. At present this form of reject has been successfully reduced in the factory to a marked degree by the use of wooden rabbles during casting.

At the Chelyabinsk Metallurgical Factory the high rejection of slabs for cracking during rolling was markedly reduced by making the reheating schedule for the ingots to be rolled more precise and by using wooden rabbles during casting.

The tendency of the metal to growth, which is exhibited during solidification of the ingots, varied.

The large number of "rising" melts at the Dneprospetsstal' factory is explained by the prolonged refining and by the temperature schedule of the melts, which provides for an especially hot running of the process.

In Fig. 2 frequency distribution curves are shown for impurities in the metal produced at the different factories. Metal in the majority of melts from the Chelyabinsk factory has a higher carbon, sulfur, manganese and nickel content. Metal in the majority of melts from the Dneprospetsstal' factory has the lowest carbon, sulfur (down to 0.005%) and chromium (down to 0.005%) content. Metal from the Kuznetsk Combine, with a somewhat higher carbon content, also has about 40% of the melts with a sulfur content less than 0.006-0.008%.

A few thousand of a percent of titanium were discovered in the metal from all three factories.

Data about the yield of top grade cold-rolled sheet (É330, GOST All-Union State Standard – 802-54) rolled from metal from the various factories (Table 3) do not allow a conclusion to be drawn regarding the advantage of any particular technique.

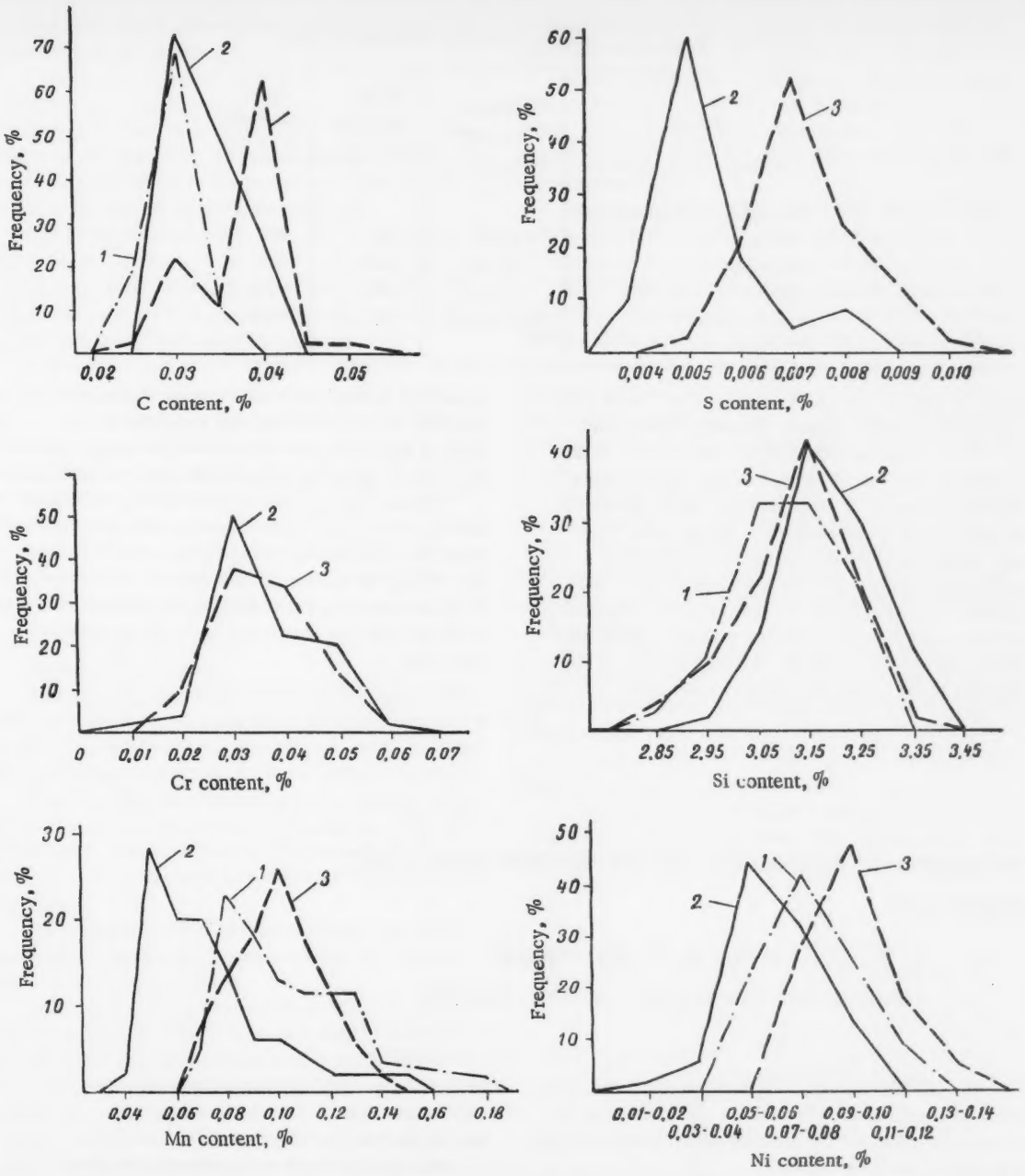

Fig. 2. Frequency distribution curves for impurities in transformer steel at different factories. 1) Dneprospetsstal'; 2) Kuznetsk Metallurgical Factory; 3) Chelyabinsk Metallurgical Factory.

In fact, the biggest yield of top grade material as sheet 0.5 mm thick was from metal from the Dneprospetsstal' factory, whereas with a thickness of 0.35 mm the greatest output was from metal from the Kuznetsk Combine. It should be noted that the quality of transformer steel was lowered in 1958 at the Novosibirsk Metallurgical Factory independently of the factory supplying the slabs (Kuznetsk Metallurgical Combine or Chelyabinsk Metallurgical Factory).

The lowest yield of grade É330 was obtained in rolling cold-rolled sheet at the Novosibirsk factory from metal from the Chelyabinsk factory. However, metal from the same factory, rolled at the Magnitogorsk Metallurgical Combine (MMK) does not

TABLE 3. Yield of Grade É330 at Various Factories in 1958

Factory	Source-Factory	Sheet thickness, 0.5 mm	Sheet thickness, 0.35 mm
Novosibirsk Metallurgical Factory	KMK	45	67
The same	ChMZ	27	46
MMK	ChMZ	49.4	62.9
Zaporozhstal'	Dneprospetsstal'	64	40.5

differ in yield of top grade material from metal from the other factories. Indeed, the properties of steel of current melts from the Cheylabinsk factory, rolled to sheet 0.2 mm thick in one factory in conditions satisfying present-day requirements for the production of cold-rolled transformer steel, hardly differ from the properties of sheet obtained under the same conditions from steel which has been melted in a vacuum induction furnace. The magnetic properties of this metal complied with the magnetic properties of top grade É380 according to GOST 802-58. Thus analysis of the results of factory magnetic-test inspection in this case does not make it possible to establish the effect of smelting technique on the yield of top grade cold-rolled sheet, evidently because of the great influence on it of the degree of reduction.

Further improvement in the smelting technique for transformer steel must evidently take place in the direction of increasing furnace production capacity, and raising the quality of the metal by the method of greater organization of the process, reducing the melt duration and developing optimum temperature schedules.

* * *

WORKING EXPERIENCE ON AN 80-TON ELECTRIC FURNACE

V. K. Petrov and B. V. Barvinskii

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The 80-ton arc furnace was prepared according to the design OKB of the Élektropech' directorate by the Novosibirsk plant for the manufacture of electrical heating appliances (see figure).*

Charging the burden into the furnace is affected from above with a basket 4500 mm in diameter and 50 m^3 in volume fitted with chain-operated release segments.

Technical Details of the Furnace

Internal diameter of housing, mm	6300
Transformer power on top voltage rating, kv-a	25000
Secondary voltage range, v	417-131
Maximum current, a	35000
Diameter of electrode discharge, mm	1750
Electrode diameter, mm	555
Electrode travel, mm	3300
Height of the melting volume (from the fore-plate to the top of the housing), mm	2300
Bath depth from the sill, mm	900

The furnace slopes are lined with magnesite bricks laid flat. The thickness of the bank at the base is 1200 mm and at the wall 600 mm. The thickness of the floor of the furnace is about 900 mm. For thermal insulation the bottom of the furnace is lined with sheet asbestos 20-30 mm thick: over this to smooth over the belts and cover-plates powdered fireclay is put down to give the bottom a spherical shape. The thickness of this layer is about 20 mm. Onto this layer two courses of fireclay bricks are laid flat. The joints in the fireclay lining

* A detailed description of the furnace was given in Metallurg, No. 9 (1959) [See English translation.]

are filled with fine-screened dried fireclay powder with a particle size not greater than 0.5 mm.

After the thermal insulation layer five courses of magnesite bricks are laid edgewise. The hearth is laid in "herringbone" fashion, working from the center of the furnace toward the walls. Each succeeding course is laid at an angle of 45° to the preceding course, so that the joints of parallel layers do not coincide.

The lining is built up dry, the joints being cut and ground to fit: the width of the joints must not exceed 1 mm. After each course, the joints are filled with dry magnesite powder with a particle size not greater than 0.5 mm and seated with wooden mallets.

The vertical part of the furnace housing is insulated on the entire height of the banks with asbestos board 10-20 mm thick and with light-weight fireclay brickwork laid as stretchets. The banks are lined with normal and transitional wedge-shaped magnesite brick laid flat. For the lining of the banks and hearth carefully graded high quality brick is used. The hearth is rammed after first warming it to a temperature of 40-50° C. The ramming mixture consists of magnesite powder with the following particle composition, %:

Particles less than 2 mm 75
Particles from 2-4 mm 25

After heating the powder to 80-85° C, 10-12% by weight dehydrated coal tar is added to it and carefully mixed. The mixture is put down on the hearth in layers 20-30 mm deep and rammed with pneumatic rammers.

The walls are lined with magnesite-chrome heat-resistant or unfired brick in metallic casings. The brick dimension is 460 and 380 mm. The wall thickness at the base is about 600 mm with a gradual transition to 450 mm.

To a height of 100-150 mm above the slag level the walls are lined with magnesite brick, but above this with magnesite-chrome.

Magnesite-chrome heat-resistant brick 300 mm in size is used for the roof. The roof is built in a cooled welded metal ring on a pattern with a rise of 750 mm. The chief central supporting arch is built up between the plugs of the electrode openings, and its ends rest on the abutment brickwork. The thrust arch between two plugs rests with one end on the central arch, and the other — on the abutment brickwork.

Then the sections (the corners of the roof) are built up: these rest on the central arch and on the abutment brickwork. Lastly the divisions corresponding to the electrode openings are made. The shaping of the brick in these courses is carried out to give the subsidiary electrode arches and the roof thickness. Building the roof is carried out dry.

The new furnace is heated up in the following way. The hearth of the furnace is covered with iron sheets and lime. Then about 60 tons of pig-iron is charged. Melting down the pig-iron is carried out at reduced transformer power and the voltage is lowered when the electrodes are being brought down near to the hearth.

When the pig-iron is melted a basic slag is formed. The molten pig-iron is held in the furnace for 3-4 hours. After pouring this pig-iron, the rammed layer of the hearth will have sintered satisfactorily and may be used for smelting steel.

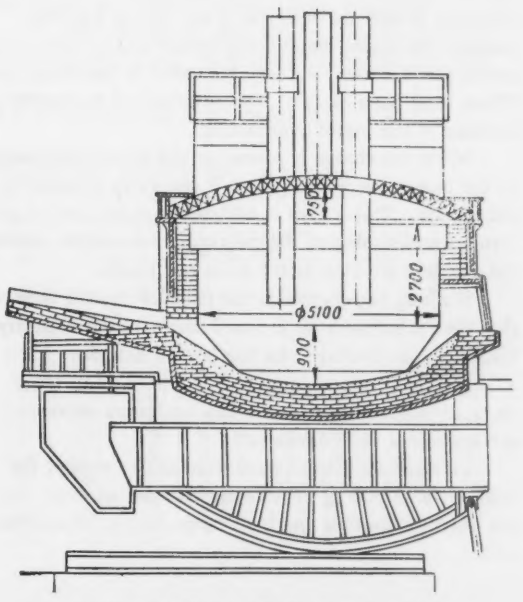
Subsequent melts on the new hearth are performed with a light heat loading. After carrying out five to six such melts normal running of the furnace is started.

The following observations have been made about the service of refractories during the use of the furnace. Furnace walls made of magnesite brick lasted 25-30 melts: from the very first melts the brickwork crumbled and was scattered onto the banks. After 10-15 melts partial wall repairs had to be carried out. Changing to magnesite-chrome brick increased the wall life to 60-65 melts.

In general the walls wear away unevenly: the greatest wear is found in zones opposite the electric arcs. It is noticed that the greatest erosion is obtained opposite the electrode with the highest power. After equalizing the power fed to each phase the wall erosion was successfully reduced.

Especially low wall-life was noted in working with a light-weight charge, the first portion charged being less than 50-55 tons. In melting down a small amount of metal, the arc is soon exposed and fuses the banks and bottom of the walls. In these places, the upper lining of the wall, having lost its support, collapses.

With noncapacity charges, conducted with the aim of protecting the furnace lining from heat-erosion, melting-down should be carried out under reduced power.



Section of 80-ton electric arc furnace.

In the case of strong erosion of the walls a partial repair is carried out by lining the damaged places with brick. Roofs made of Dinas (a silica refractory) brick 300 mm in size break down after 11-15 melts. Magnesite-chrome roofs last 60-85 melts without partial repairs. It is noticed that toward the campaign end with comparatively small erosion of the brick (about 50%) the roof center begins to sink and the peripheral parts bulge out.

The inadequate mechanical strength of the roof lining is also connected with the use of a large number of trimmed bricks in the assembly: this is because the magnesite-chrome heat-resistant brick is made in sizes suitable for open-hearth furnaces without regard for the requirement of electric-furnace steel-smelters.

In order to increase the mechanical strength of the roof center, it was decided to use, instead of sunk-in cooling rings, ones that are supported and laid on top.

Working experience has shown that to increase the life of the furnace lining and to make it suitable for melting transformer steel the furnace casing must be broadened thus making the walls inclined, and a heat-resistant brick not containing chromium must be used for lining the walls and roof; magnesite heat-resistant brick in a spinel compound must be tested, and suspended roof design must be developed and tested in the near future.

Steel-Melting Technique. In the first days of working the shop the ordinary technique was adopted. However, when this was done difficulties peculiar to the large furnace arose.

Phosphorus-removal from the charge in the boil period requires a large amount of lime and ore. This operation takes up much labor and time. A sufficiently thorough phosphorus-removal is not always achieved because the metal may be overheated and the necessary amount of lime and ore may be added at the wrong time. There have been cases of the disruption of the hearth because of the metal overheating.

When the charge is placed in the furnace by means of the basket the working door is generally covered by the charge. This makes it difficult to carry out the slag formation desirable in the melting-down period, and so the exposed arc attacks the walls and banks.

Working experience in the first few months showed that the technique used in small and medium capacity furnaces was unsuitable for the 80-ton furnace.

By taking into account the peculiarities of large capacity electric furnaces, a new and more rational technique has been developed.

To form the slag in good time and to protect the hearth, about 600 kg of lime are charged on to it. If the hearth is shallow and the charge heavy, lime is not added.

The charge-calculation for melts is carried out so that the carbon content in the charge should be 0.30 0.35% above the lower limit for the steel being smelted. Loading the entire charge should be effected in 1-2 portions (the bulk weight of 1 m^3 of charge should be not less than 1.6 tons).

To combine the melt-down period with dephosphorization, lime – 2.5-3.5% of the charge weight – is added with the second portion of the charge, together with ore, the amount of which should give a carbon content in the metal after melt-down near to the upper limit for the steel being smelted.

As a rule, melting is carried out at the maximum transformer power. With a noncapacity first charging (less than 60 tons), in order to protect the hearth from attack by the arc, melting is carried out at reduced power. Toward the end of melting-down each portion of charge the transformer power is reduced.

To undercut the charge with oxygen, tubes 3/4 inch in diameter are used.

Toward the end of melt-down the slag should be fluid, frothy and should flow by gravity over the sill of the working door.

Such a technique without a prolonged boil makes it possible to obtain a phosphorus content below 0.015% at melt-down of the metal.

A small boil is necessary to equalize the temperature throughout the whole bath. Refining is carried out according to the standard technique under a white or weakly carbide slag.

The stator of the magnetic stirrer is switched on for 10-15 minutes at the end of melt-down, for the whole time while the slag is being run off and for 3-5 min in taking samples or measuring the temperature of the metal.

The duration of the various operations in the melt has recently been, hr-min:

Maintenance	0	43
Charging	0	11
Melting-down (including time taken in making additional charge-additions)	3	44
Boil	0	20
Slag removal	0	10
Refining	0	47
Total	5	55

The technique now adopted for smelting plain carbon steel in the 80-ton furnace has proved satisfactory. Experience has shown that in such furnaces with an appropriate steel-smelting technique it is possible to secure all requirements made as to the quality of the metal.

INTENSIFICATION OF THE REDUCTION REGIMES WHEN COLD ROLLING STRIP

M. A. Benyakovskii and V. P. Volegov

Ural Scientific Research Institute of Ferrous Metals

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The most effective method of increasing the productivity of rolling mills is to roll the metal with increased reductions. Results are given below of the study of the possibility of intensifying the reduction regimes when cold rolling strip made of carbon and alloy steels on the 740 mm mill.*

The mill consists of three stands with 520 × 810 mm work rolls and 1100 × 740 mm backing-up rolls. The bearings of the backing-up rolls are of fluid friction. Each stand is driven by 1000 hp dc motors at a rated current of 1300 amp. The mill is equipped with an uncoiler in front of the first stand and a coiler-tension machine after the third stand, motor power of which is 500 hp.

During rolling, the rolls and strip are supplied with an emulsion consisting mainly of mineral oils. The permissible pressure of the metal on the rolls according to the operating conditions of the fluid friction bearings is 1300 tons.

Strips 650 mm wide with an initial thickness of 2.5-4.5 mm are rolled to a final thickness of 0.5-2.0 mm on the 740 mm mill.

Dynamometers with wire resistance pickups were used during the investigation to measure the pressure of the metal on the rolls and the tensile forces.

The basic parameters characterizing the rolling regime (the pressure of the metal on the rolls, the strip tension, current, voltage, motor speed of each stand and coiling machine) were recorded on the oscillograph tape. The thickness of the strip during rolling was controlled by the readings of the flying micrometer gauge installed beyond the third stand of the mill and was also measured by a hand micrometer after the first and second stand.

Table 1 shows the rolling regimes of the main standard-size strips according to the technology usually used in the shop, the results of measuring the pressure of the metal on the rolls, and the loads on the main motors of the mill under these conditions.

It is apparent from the table that when rolling certain strips the pressure of the metal on the rolls and the load on the motors of the stands are considerably below those permissible. Experimental groups of strips were rolled with increased reductions or without intermediate annealing in order to find out if it was possible to increase the output of the mill.

Thus, strips made of steels 08 rimmed, 20 dead melted, 40, and 30 KhGSA were rolled to the required size in one pass instead of two, and the strip 2.0 × 525 mm made of steel 65G was rolled to 1.3 × 525 mm in two passes but without intermediate annealing.

Table 2 shows the data on the power and energy conditions of rolling strips under intensified regimes.

*V. K. Fridrikhsen participated in the work.

TABLE 1. Power and Energy Conditions for Rolling Strips by the Ordinary Technology

Steel	Sizes, mm		Thickness of strip by stands, mm			Total reduction, %	Force of rolling in stands, tons			Tension of strip between stands, tons		Load on motor in stands, amp		
	Flat product	Finished strip	I	II	III		I	II	III	I–II	II–III	I	II	III
08 rimmed	2.5×600*	1.2×600	1.75	1.35	1.2	52	610	590	515	6.7	6.4	800	940	590
	1.2×600**	0.8×600	1.0	0.9	0.8	33	735	650	490	7.0	5.0	77	1230	425
20 dead melted	4.5×600*	2.6×600	3.9	2.8	2.6	42	1130	825	540	7.0	6.9	1280	1120	940
	2.6×600**	2.0×600	2.3	2.1	2.0	23	1030	825	465	6.6	7.0	1130	490	270
40	2.0×600*	1.4×600	1.7	1.5	1.4	30	720	825	540	6.6	7.2	335	700	425
	1.4×600**	1.0×600	1.25	1.05	1.0	28.5	890	1030	490	6.5	6.9	335	910	565
20KhGSA	2.5×600*	1.5×600	2.0	1.65	1.5	40	755	1160	1225	6.7	7.1	1210	1120	755
	1.5×600**	1.2×600	1.35	1.25	1.2	20	1170	1085	685	6.8	7.0	900	800	190
65G	2.0×525*	1.7×525	1.83	1.74	1.7	15	700	780	245	6.8	7.0	51	655	352
	1.7×525***	1.3×525	1.45	1.33	1.3	23	905	672	564	7.1	7.3	51	1000	518

*Hot-rolled.
**Cold-rolled.
***Annealed.

TABLE 2. Power and Energy Conditions of Experimentally Rolled Strips

Steel	Sizes, mm		Thickness of strip by stands, mm			Total reduction, %	Force of rolling in stands, tons			Tension of strip between stands, tons		Load on motor in stands, amp		
	Flat product	Finished strip	I	II	III		I	II	III	I–II	II–III	I	II	III
08 rimmed	2.5×600*	0.8×600	1.4	0.95	0.8	68	1100	900	725	7.1	6.6	1520	1120	564
20 dead melt	4.5×600*	2.0×600	2.9	2.2	2.0	55.5	1280	1000	540	7.4	7.0	1300	940	1040
40	2.0×600*	1.0×600	1.4	1.08	1.0	50	1250	1130	612	7.0	7.2	1050	980	425
30KhGSA	2.5×600*	1.2×600	1.7	1.28	1.2	52	1210	1130	856	7.5	7.5	1030	980	870
65G	2.0×525*	1.6×525	1.8	1.65	1.6	20	775	825	270	7.0	7.0	514	750	350
	1.6×525**	1.3×525	1.45	1.33	1.3	18.5	945	1110	834	7.4	7.1	284	940	470

*Hot-rolled.
**Cold-rolled.

According to this data, rolling of steel 40, 30KhGSA, and 65G in the case of intensified reduction regimes does not lead to an increase in the pressure of the metal on the rolls and of the load on the motors of the mill beyond those permissible. In addition to this the experiments showed that, for example, when rolling strips of steel 08 rimmed having initial dimensions of 2.5 × 600 mm the load on the motor of the first mill becomes greater than the rated load for one pass to the final dimensions of 0.8 × 600 mm.

In conformity with the results of the investigation the following changes were introduced into the technology of rolling strip on the 740 mm mill. We began rolling strips of steel 40 and 30 KhGSA not in two passes but in one pass in conformity with the reduction conditions indicated in Table 2. In the case of rolling strips made of steels 20 dead melted and 08 rimmed we used a thickness of 2.0 instead of 2.5 mm, which also made it possible to produce finished strips of the required dimensions (1.0 × 600 mm from steel 20 dead melted and 0.8 × 600 mm from steel 08 rimmed) in one pass; the pressure of the metal on the rolls and the load on the motor did not exceed the permissible values.

Rolling of strips in one pass instead of two permitted us to increase considerably the output of the mill.

* * *

IMPROVEMENT IN THE LUBRICATION OF SPINDLE COUPLINGS OF ROLLING MILLS

S. M. Nosenko, Chief of the Plate and Sheet Shop of the Voroshilov Plant and Candidate of Technical Sciences B. P. Rumyantsev

Voroshilov Mining-Metallurgical Plant

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Spindle couplings of modern rolling mills operate under very heavy conditions. Rapid wear of the bearings, especially from the side of the rolling stand, increases the play in the drive system, which involves the development of a peak impact dynamic load. Usually the spindle bearings are manufactured from aluminum-iron bronze AZh-9-4, which ensures high wear resistance of the parts under conditions of copious lubrication and high hardness of the friction surfaces.

Lubrication of the spindles of modern rolling mills is accomplished from a general, centralized system for heavy lubrication of the mill equipment (Fig. 1). It is assumed that the lubricant being supplied from the measuring feeder to the cavity of the collar mill maintains pressure sufficient for forcing the lubricant through drill holes to the friction surface of the spindle coupling. In practice such a device turned out to be unworkable due to the clearances between the collar and the spindle through which the lubricant was forced. A decrease in the clearance caused the collar to wedge and turn in the recess thus destroying the entire structure or caused a rapid enlargement of the initial clearance.

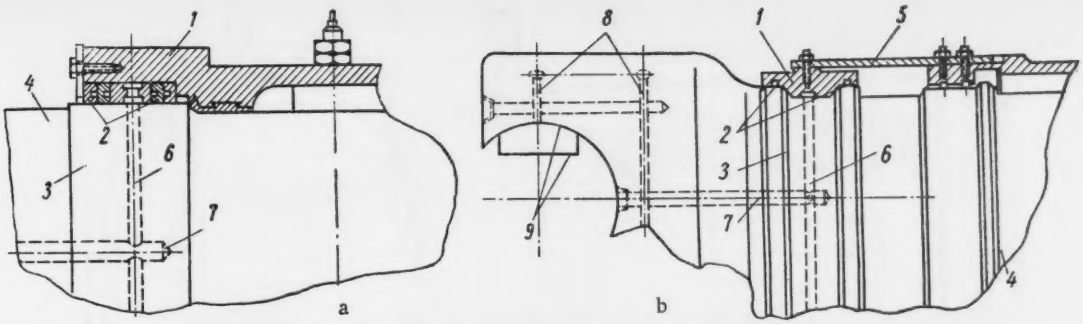

Fig. 1. Device for lubricating spindle couplings: a) Design of the Ural Heavy Machinery Plant; b) design of the Novo-Kramatorskii Heavy Machinery Plant (1700-mm mill); 1) split collar; 2) packing; 3) groove; 4) spindle body; 5) plate; 6) radial hole; 7) central hole; 8) side hole; 9) friction surfaces of the coupling.

The use of spindles with special tanks at their heads for oil lubrication of the couplings was also ineffective due to a number of objective reasons.

Therefore at the majority of plants the spindle couplings are lubricated manually during preventive maintenance of the mill by grease guns through openings in the spindle head. This requires much time and manual labor.

On the other hand the desire for the best lubrication of the couplings leads to filling the spindle with a large amount of lubricant, which during the first revolutions of the spindle is ejected, thus not being of any benefit to the operation of the coupling and contaminating the surrounding equipment. In this case a great amount of lubricant is uselessly expended because the friction surfaces can take only a small portion of lubricant, but at the same time require its systematic replenishment.

On certain mills oil is simply poured over the spindle coupling during shutdowns, which in general is ineffective and intolerable.

The workers of the Voroshilov Plant and the machine-parts department of the Alchevskii Mining-Metallurgical Plant, taking into consideration the unsuitability of the lubrication of the spindle couplings designed for the 1700-mm mill (see Fig. 1), developed a new design for spindle lubricating devices.

Many years of operating experience confirms the complete suitability of oil lubrication of the spindle couplings. Thus, for example, oil lubrication from the side of the pinion housing ensured excellent resistance of the bearings on the 2250-mm mill at the Voroshilov Plant; from the start of operation of the mill (1954) to the present the bearings have not been considerably worn.

Oil lubrication of spindle bearings was applied from the central lubricating system of the reducing gears and pinion housing.

The existing methods of clearing the oil in the circulation system, although the oil leaving the spindles somewhat increases contamination, assure its adequate purification. Therefore, connection of the spindle to the central lubrication system should not have any effect on the lubrication of the gears and bearings of mill drives.

Oil lubrication of spindle couplings from the side of the pinion housings is accomplished in the following manner (Fig. 2): the existing end plates of the pinion housing from the side of the spindles are replaced by special covers consisting of a lower and two side parts enclosing the spindle heads. The joints of the covers are implemented with lubrication stops which prevent leakage of the lubricant. A labyrinth seal is installed at the outlet of the spindles from the covers. A trap door is provided (through which examinations are made of the spindle joint and lubricating nozzles) which is well protected from oil leakage. The bearings are covered with a special shield so that dirt or foreign substances do not fall from the spindle covers into the bearings of the pinion housing.

The essence of the new method of lubricating is that the stream of lubricant leaving at high speed from a special nozzle is directed so that at a certain position of the spindle head (Fig. 3a) the lubricant enters the hole which conducts it to the working friction surfaces of the bearings. In this way a supply of lubricant is provided to the unloaded surfaces of the bearings through the gaps and special oil passage located there. Here the atmosphere of an oily fog will provide an oily film over all surfaces, and a stream of lubricant copiously poured over the head of the spindle simultaneously helps to cool it. Since the lubricant of the spindle heads is enclosed in a circulation system its consumption is kept to a minimum.

Such a system of lubrication can also be used successfully in a drive without reducing gears. In this case it is necessary to install a special, small circulation system for lubrication.

During reverse operations of the spindle device it is necessary to install two nozzles on each head which

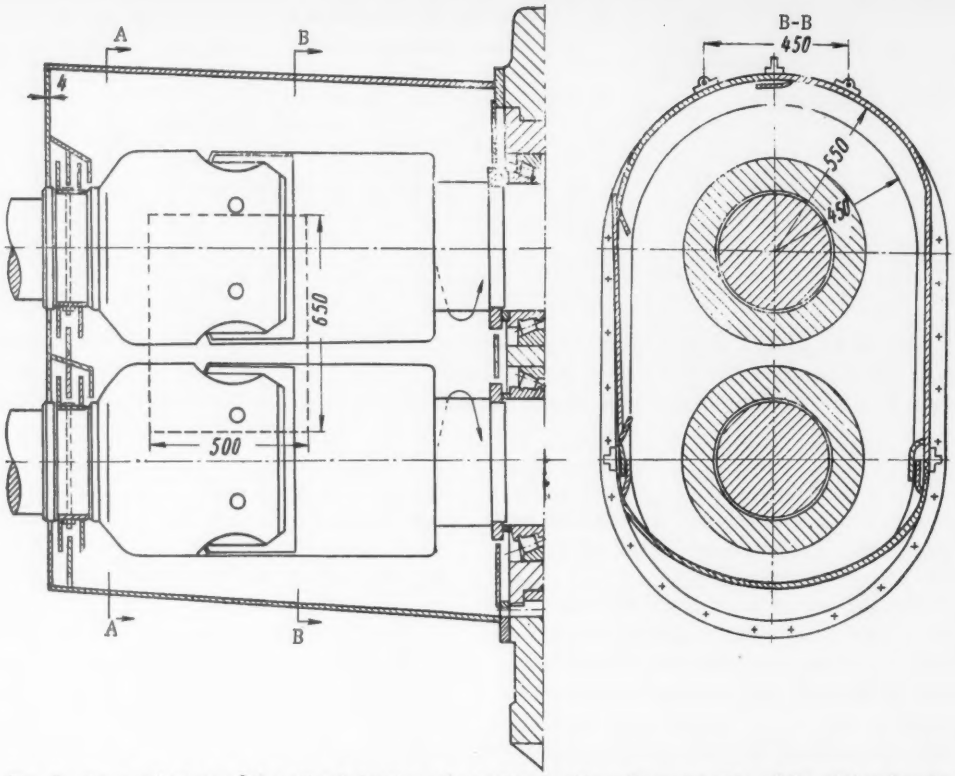

Fig. 2. Over-all view of the oil lubrication of spindle couplings from the side of the pinion housing.

will provide copious lubrication to all friction surfaces of the spindle coupling since each of the surfaces alternately becomes a working surface.

It is more complicated to lubricate the spindle couplings from the side of the roll stand where it will hardly be expedient to use the aformentioned oil lubrication of the spindle couplings because of the smaller dimensions, the considerable shifts and vibrations, the frequent roll changing, and the presence of water and scale in the operating zone of the spindle heads. Therefore two constructional variations were developed for forcing heavy lubricants to the spindle couplings from the side of the roll stand: the first (Fig. 4) is mainly for slow-speed (to 50 rpm) and the second for fast-speed nonreversing spindles. In the starting position, with the system fully primed, there is a sufficient amount of lubricant in the eight main piston cylinders for operating the spindle heads with lubricated friction surfaces for 5-7 days. The thrust ring and the pistons of both systems originally occupy the extreme right position. With the start-up of the mill and the beginning of operation of the heavy lubrication system the pushing piston cylinders receive lubricant under a pressure of 25-40 atm. With an increase in the pressure in front of region A (Fig. 4) the piston-push rod is moved to the left thus moving the rings, which in turn moves the working pistons producing in region B and in the entire following lubrication system a pressure sufficient for delivering the lubricant to the friction surfaces of the spindles. Since the intermediate mechanical links of this lubricating system have a certain "spring" the delivery of lubrication to the bearings will be virtually constant, which to the greatest degree corresponds to the lubrication requirements of the surfaces during sliding friction.

During a systematic check the working cylinders are filled with a new portion of lubricant from the branch of the main oil line of the SAG system, and the lubricant from the pushing cylinder is pressed out through the return line to the reservoir of the central system.

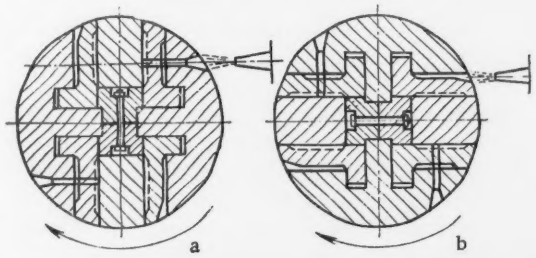

Fig. 3. Oil lubrication of a nonreversing spindle coupling : a) Lubrication of the working surfaces of bearings; b) lubrication of nonworking surfaces of a bearing during a 90° turn of the spindle relative to position A-A.

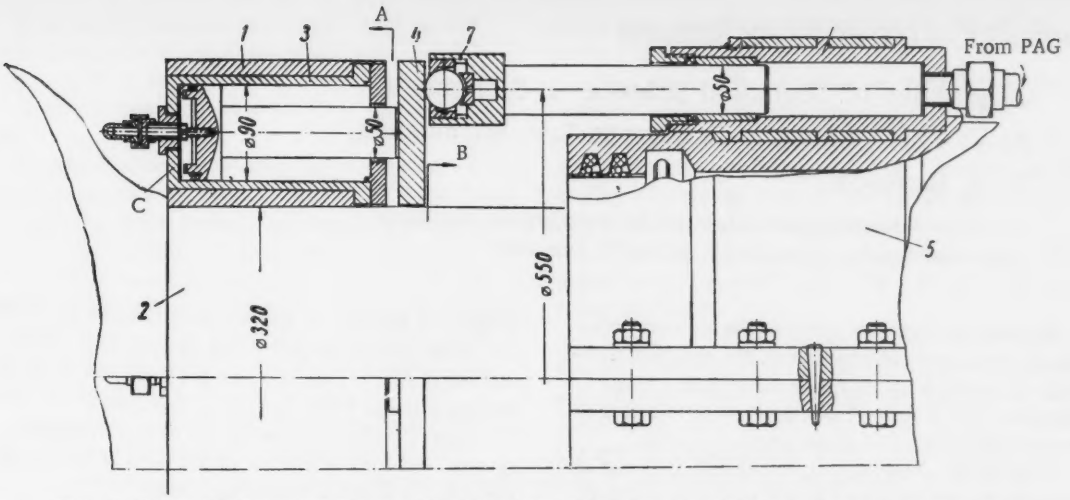

Fig. 4. Design for heavy lubrication of spindle joints from the side of the roll stand: 1) casing; 2) spindle body; 3) cylinder with piston; 4) thrust ring; 5) block bearing; 6) piston cylinder; 7) rolling device.

The device for lubricating high-speed nonreversing spindles is shown in Fig. 5.

During each revolution of the driven pulley relative to the driving pulley the cam is located at the plungers which will deliver the next portion of lubricant to the surface being lubricated. The relative rotation of the pulleys is attained by the difference in their diameters and the diameter of the tension pulley has no effect on the ratio of the drive.

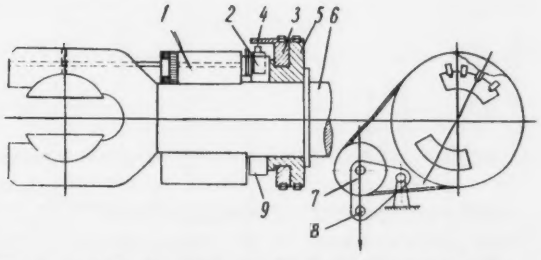

Fig. 5. Lubrication of a spindle joint by a lubricator having a V-belt drive: 1) Reservoir; 2) four-plunger pump; 3) driven pulley; 4) cam; 5) driving pulley; 6) spindle; 7) tension pulley; 8) load; 9) clips.

If a rachet, which assures rotation in only one direction during reverse operation, is installed on the moving pulley then this lubrication device will be universal for any spindle coupling.

The parts of the lubricator and the units of the lubrication device are made interchangeable and easily removeable which enables possible troubles to be eliminated quickly.

The use of the new devices for heavy lubrication of spindle couplings from the side of the roll stand and for oil lubrication from the side of the drives offers the following main advantages: a) it eliminates labor-consuming operations of manual lubrication of the spindles; b) it automatically provides the optimum lubrication conditions of the friction surfaces of spindles; c) it considerably cuts down the expenditure of parts made of hard-to-get nonferrous metals, reduces lost time and expenditure of the labor force for repair and replacement of parts in the spindle equipment; d) it considerably cuts down the outlay for high-price lubricants; e) it reduces the impact loads in the drive system of the rolling stand, which favorably affects the operation of all units of the mill and in particular the durability of the rolls.

* * *

OPERATION OF ROTARY SHEARS

Candidates of Technical Science I. S. Pobedin,
A. V. Tret'yakov and Engineers L.V. Shchepnina,
V. A. Revunov

All-Union Scientific Research Institute for Metallurgical Machinery
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Experiments were conducted at the Moscow Tube Plant for the purpose of establishing the optimum technology of cutting strips on rotary shears with a blade diameter of 268 mm, 9-11 mm thick, with a cutting speed of 0.35 m/sec at a motor power of 7.5 kp.

Strips made of steels St. 3, 1Kh18N9T, 65G and of aluminum and duraluminum to 200 mm wide and 1-10 mm thick were cut.

The experiments showed that the following factors affect the magnitude of force and cutting operation of rotary shears: the diameter of the blades, the overlap, the side gap between the blades, the rake and degree of dulling of the blades, the mechanical properties, and the dimensions of the strip section being cut. These factors to a greater or lesser degree also affect the surface quality of the cut and blade wear.

Strips of various thicknesses were cut with side gaps of the blades between 0-0.05 mm and overlaps from minus 2 to plus 10 mm in order to study the effect of the blade overlap. As a result of processing the experiment oscillograms we established that with an increase in the overlap the cutting force at first was reduced and then at greater overlaps begins again to increase (figure); the decrease and subsequent increase in the cutting force in the region of positive overlaps occurs more intensively for strips of greater thicknesses; in the region of negative overlaps, i.e., when parting the blades, the cutting force is increased; with an increase in the blade overlap the cutting moment is increased.

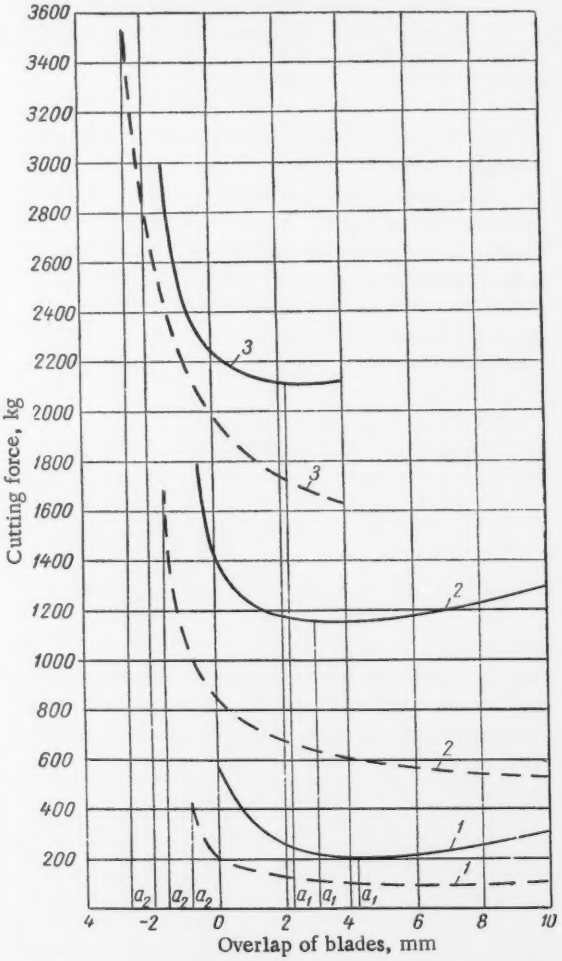
A good quality cut was observed while cutting strips 4-8 mm wide made of various steels and with positive overlaps from 1 to 5 mm. The edge of the cut with a 1-mm overlap is 20-30% of the crumpled zone and 80-70% of the shear zone (30% in respect to soft metals). The crumpled zone increases with an increase in the overlap and decreases with its decrease. With overlaps of 0 or minus 1 mm the crumpled zone disappears. An uneven surface of the cut is produced with a further decrease in the overlap.

When cutting strips 1-2 mm thick a good quality cut was obtained with a positive overlap of 2-6 mm. The quality deteriorated with a decrease in the overlap. Soft metals were not cut when the overlap of the blades was only minus 1 mm.

With an increase in the side gap the cutting force at first decreased and then increased. At a certain value of the side gap the cut stopped (only bending occurred).

When cutting strips 4-8 mm thick a good quality cut was observed when the side gap was 0-0.4 mm (for soft metals) and 0-0.5 mm (for brittle metals).

With a further increase in the side gap roughness, troughs and burrs developed on the edge of the cut and then the cut stopped, becoming a bend.



Dependence of cutting force on overlap of blades for strips of various thickness made of steel St. 3: 1) Thickness of strip 1.1 mm; 2) 2.2 mm; 3) 3.7 mm: ---------- cutting force according to the experiment; - - - - - - - cutting force according to V. V. Nosal's formula.

When cutting strips 1-2 mm thick a good quality cut was observed with a side gap of not more than 0.2-0.3 mm. With an increase in the side gap the shear zone sharply increased and the quality of the cut became worse.

An investigation of the durability of the blades was made on rotary slitting shears at the Moscow Tube Plant. The durability of the blades in influences by the material of the blades, their heat treatment, hardness, etc. Blades made of steels U8, 9KhS, 5KhNB, ShKh15, 5KhV2S of Rockwell hardness C-45-65 were investigated. We used these steel blades to cut strips 1.5-2.5 mm thick made of steels 10 and 20 both cold rolled with copious lubrication and hot rolled with scale (without pickling).

The observations showed that blades of any steel of Rockwell hardness C-62-65 rapidly chip and with Rockwell hardness C-45-48, they rapidly become blunted.

We established that blades having the best durability are those made of steel 5KhV2S of Rockwell hardness C-55-60 (12-15 replacements when cutting cold rolled strips and 6-9 replacements when cutting hot rolled unpickled strips).

As a result of investigating the process of cutting with industrial rotary shears we established that:

1. For producing a quality cut the overlap of the blades should not be negative and the maximum positive overlap – within the limits of the holding device of a strip without a bottom support – is 1-5 mm.

2. Side gaps are recommended within the following limits: 0-5% S for A1M, and 0-10% S for D16, 65G, St. 3 and 1Kh18N9T.

3. The following minimum ratios of the thickness of the strip being cut to the blade diameters were obtained while cutting metal without a bottom support with the blade setting within the recommended ranges of overlap and side gaps between them: 1 : 45 for A1M and D16, 1 : 65 for St. 3 and 1Kh18N9T.

4. The best blade durability was attained when cutting with blades made of steel 5KhV2S of Rockwell hardness C-55-60.

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COLD DRAWING OF TUBES WITH AN OXIDE FILM

M. A. Freiberg, Deputy Chief of the Tube Drawing Shop and V. I. Moskalenko, Chief of the Technological Group

Pervouralskii New Tube Plant

Translated from Metallurg, No. 6, pp. 32-33, June 1960

When cold drawing tubes, friction forces arise on the contact surfaces of the metal being deformed and of the tool thus hampering the drawing process. In order to reduce these forces the tubes prior to drawing are copper clad or phosphate coated and oil treated in a fatty lubricant or in a soapy emulsion.

Presently at many drawing shops in the country, copper cladding has been replaced by phosphate coating since this coating has better antifriction properties and permits applying deformations 20-25% greater than with copper cladding. The phosphate coating process is composed of the following technological operations which are accomplished in the pickling department:

1. Assembly of the tubes into bundles with separation of the horizontal rows by cross pieces;

2. Pickling in a solution of sulfuric acid at 60-75° for 30-60 min at a sulfuric acid concentration of 10-22%;

3. Washing the tubes in a bath with cold running water;

4. Washing by a stream of water from a fire hose under a pressure of 8-12 atm;

5. Neutralization in a bath with an alkaline solution containing 0.5% soda ash;

6. Washing in a bath with hot water;

7. Phosphate coating in a bath with a solution containing 15 g/liter of zinc oxide, 18 g/liter of nitric acid, and 8 g/liter of phosphoric acid.

Tubes which are subject to drawing on a short mandrel are prepared according to this technology. In those cases when tube drawing is done without mandrels the operation of assembling the tubes into bundles is eliminated. All other operations remain, which creates great strain in the operation of the pickling departments.

Since the inner surface of the tubes when drawing them without a mandrel does not come into contact with the tool there is no need in preparing its antifriction properties. Therefore for tubes made without mandrels their preparations for drawing are limited which makes it possible to conduct the deformation process with observance of the surface quality requirements of the tubes. In this way the tubes are prepared by copper cladding them before drawing.

The tubes are copper clad in the pickling department of the tube-drawing shops according to the following technology:

1. Gathering the tube bundles into cramps;

2. Pickling in a sulfuric acid solution at 50-75° for 20-40 min with a sulfuric acid concentration of 10-22%.

The pickling time depends on the type of steel, the sulfuric acid concentration, and the content of green vitriol in the sulfuric acid solution. With an increase in the quantity of green vitriol and a decrease in the concentration of sulfuric acid in the solution the activity of the bath drops and the pickling process is forced by an increase in the temperature of the solution;

3. Washing of the tubes in a bath with cold running water for 4-5 min;

4. Washing with a stream from a fire hose under a pressure of 8-12 atm;

5. Copper cladding in a bath with a solution of 3-4% blue vitriol and 2-3% sulfuric acid in water at 18-22° for 2-4 min;

6. Washing in a bath with hot water.

The number of tubes made without a mandrel in the assortment of the tube-drawing shops depends on the relationship of the number of cold-rolling mills and tube-drawing mills in each shop. With a sufficient number of cold-rolling mills the wall thickness of the tubes are prepared on these mills and further deformation of the tubes is done by drawing without mandrels.

Tubes made without mandrels consist of 50-70% of the total number of tubes passing through the pickling department. While searching for a way to increase the output of the pickling department and to improve the surface quality of the tubes, the workers of the tube-drawing shop of our plant developed a new technology of preparing mandrel-less tubes for drawing which eliminates both phosphate coating and copper cladding. In the new technology copper cladding and washing in hot water is eliminated and replaced by a more prolonged washing of the tubes with a stream from a fire hose. While washing with a cold stream of water and upon further holding of the bundle in the air for 7-10 min, an oxide film (rust deposit) forms on the outside surface of the tubes which when washed in a soapy emulsion bath is a good antifriction coating, better than phosphate or copper.

The oxide film coating is easily formed on tubes made of all carbon steel and also on tubes made of alloy steels 12KhMF, 15M, 15KhM, 12MKh, 15Kh, 40Kh, 30 KhGSA, 12Kh2MFSR, and others.

The new technology permits each pickling department to save 90 tons of blue vitriol per year and also to cut down the number of crane operations.

Drawing of tubes with an oxide film is conducted along the existing routes in the shop and with the usual drawing tool: the rings and drawing dies are made of steel 12Kh5Ma and of hard alloy VK-8.

The durability of the tool when operating according to the new technology increased and the surface quality of the tubes was improved. In October 1959, 2230 bundles of oxide-film coated mandrel-less tubes were drawn, of which 1368 bundles were of finished sizes; in November, respectively, 2657 and 1653, in December 2752 and 1740 bundles.

In October, 1,011,290 m of tubes were manufactured by the new technology wherein rejects due to scratches on the outer surface were 909 m (0.09%), in November, 1,182,000 m were manufactured and rejects for scratches were 1711 m (0.14%), and in December, 1,285,000 m were manufactured and rejects were 1612 m (0.12%). Previously, when drawing tubes with preliminary phosphate coating or copper cladding, rejects due to scratches on the outer surface were 0.18-0.22%.

The annual savings from introducing this new measure is 230,000 rubles per drawing shop.

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A NEW AND USEFUL BOOK FOR WORKERS IN INDUSTRIAL TRANSPORTATION

B. I. Eliokumson, M. A. Mitrofanova, A. N. Gavrilyuk, M. G. Baltaksa, Litvinenko, and K. D. Belykh

Dzerzhinskii Plant

Translated from Metallurg, No. 6, p. 33, June 1960

Industrial railroad transportation at metallurgical plants differs greatly from railroad transportation on the main lines. Therefore the organization of transportation which is applicable to the railroads of the Ministry of Railroads cannot be mechanically transferred to industrial railroad transportation.

Technical literature has heretofore thrown insufficient light on the problems related to the organization of railroad transportation at metallurgical plants. Therefore the railroad workers of the plant greeted A. K. Averbukh's book, "The Organization of Railway Transportation at Metallurgical Plants" with special satisfaction; this book, published by the State Metallurgical Press in 1959, was the first to elucidate systematically and orderly the entire complex of problems related to the organization of industrial railroad transportation.

This book explains in detail the problems of the fundamental operation of railroad transportation at metallurgical plants, of the organization of plant posts and stations, the traffic capacity of railroad stations and runs, and the organization and administration of intra-plant railroad transportation.

The book elucidates the most advanced practice of operating railroad shops, in the generalization and introduction of which the author actively participated, and also new theoretical developments. The material of the book is well arranged and stated in simple language.

The book is a valuable reference guide. In addition to this it renders great aid to plants in the development and introduction of the most thorough systems of organizing intra-plant railroad transportation and in improving the operation of industrial railroad transportation.

Unfortunately the book has a very small circulation (only 1700 copies) and therefore many transportation workers will not be able to acquire this valuable and useful publication.

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ADVANCED EXPERIENCE IN THE PRODUCTION OF FERROSILICON ALLOYS

Yu. S. Maksimov and Ya. S. Shchedrovitskii

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An interplant school on the study of advanced experience in the production of ferrosilicon alloys was held in June-July 1959. The participants of the school visited seven plants. Special attention was devoted to improving technology, to the operation of equipment, and to the organization of production. Questions of the cost of production, labor productivity, electrode service, labor safety, etc.,were also studied.

The school began its work with the study of the experience of the Kuznets Ferroalloy Plant. Here the difference in operation was noted when smelting ferrosilicon of one type in different furnaces.

Thus the consumption of electric energy when smelting 45% ferrosilicon varied in furnaces within 4500-4700 kw-hr, and when smelting 75% ferrosilicon it was 9050-10370 kw-hr per one basc ton.

The use of low-quality coke fines is the main reason for the increased consumption of electric energy. A sieve analysis made by the participants of the school established that of the coke fines delivered to the furnaces, 31.3% had sizes greater than 20 mm and 6% less than 4.5 mm.

It is known that large-size coke (greater than 20 mm) considerably increases the electrical conductivity of the ferrosilicon bath; this interferes with deep immersion of the electrodes into the charge and causes an overconsumption of electric energy.

It must be added that the coke of the Kuznets Metallurgical Combine, which the plant requires, has almost 1.5 times greater electrical conductivity than the coke of the Kemerovo Plant.

The participants of the school noted that the coke used in the furnaces of the Zaporozh Plant is devoid of pieces larger than 20 mm. This permitted the Zaporozh ferrosilicon workers to obtain good results when smelting not only 45% but also 75% ferrosilicon. The consumption of electric energy in the furnaces of the Zaporozh Plant averaged 20% less than in the furnaces of the Kuznets Plant.

The school recommended that the Kuznets Plant organize correct sieving and crushing of the coke, which will significantly improve the operation of the furnaces.

In the coke used at the Serov Ferroalloy Plant 19% of the fines were smaller than 4.5 mm.

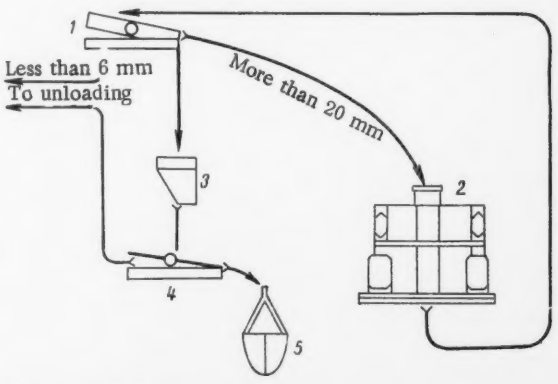
As the participants of the school explained, the coke fines contained in the charge do not act as a reducer: the fines are either completely carried away by the gases through exhaust pipes or burn on the surface of the top apparatus. In addition to this the fines obstruct and damage the top, hampering the uniform escape of gases.

The school recommended that all metallurgical enterprises emulate the practice of the Chelyabinsk Ferroalloy Plant which reduced the content of fines in coke (smaller than 4.5 mm) to 3%.

It is necessary to note that dual-roller coke crushers, which do not give good crushing, were installed in new ferroalloy shops designed by the State Institute for the Design and Planning of Metallurgical Plants and Establishments. At the same time our industry produces four-roller crushers which have been highly recommended at the Zaporozh Ferroalloy Plant.

The school recommended to introduce everywhere the diagram of preparing coke shown in the figure.

The participants of the school discovered a sharp difference in the staffs of workers servicing the ferroalloy furnaces. Thus at the Chelyabinsk plant, where charging is done by shovel, 22 chargers work in addition to the smelters and furnace attendants. But at the more



Recommended Diagram for screening and crushing "nut" coke: 1) Screen with 20 and 6 mm meshes (8 mm during wet times of the year); 2) four-roller crusher; 3) measuring bunker; 4) shaker with 6 (8) mm control sieve; 5) measuring car.

powerful furnace of the Kuznets Plant only 8 persons are occupied (excluding the senior smelters and furnace attendants). Charging machines designed by P. S. Plyuiko are used here for charging.

The collectives of the Kuznets and Zaporozh Plants constantly improve the charging machines, which improves the charging process and reduces idle times of the machines.

In order that the charge is loaded in greater mounds, as practice shows, it is necessary to use quartzite that is not larger than 80 mm. The machine adequately services the top when the level of the top is below the working area.

The experience of the Zaporozh and Lipets Ferroalloy Plants showed that when charging with machines it is expeditious to reduce the size of the round, calculating it per 200 kg of quartzite, whereby a more uniformly heated charge is delivered to the bath. The school became familiar with the interesting practices of agglomerating the charge. At the Kuznets Plant, when smelting 75% ferrosilicon, a portion of the steel shavings were replaced by fluxing sinter, which did not produce the specified effect. Sinter which contains all the constituents of the charge is partially used at the Zaporozh Plant. Unfortunately after a number of reloadings during transportation this sinter had too many fine pieces.

The machines designed by P. S. Plyuiko continuously operated without protection from the heat radiation of the top, which produced difficult conditions at the working area. According to the measurements made by the participants of the school, at the Zaporozh Plant the temperature at the working area reached 60° at a distance of 1.7 m from the side of the furnace.

V. S. Dolgushev, mechanic at the Chelyabinsk Ferroalloy Plant, suggested the installation of shields which the charging machine itself depresses and releases while moving around the furnace. Such shielding makes it impossible to reduce the temperature in the working area by half.

The participants of the school also became familiar with the experience of operating rotary furnaces.

It was established at the Kuznets Plant that when smelting 45% ferrosilicon the best results are obtained when the rotational speed of the furnaces is not more than one revolution per 36 hrs. With an increase in speed the metal bath begins to draw the electrodes toward the direction of rotation. When smelting 75% ferrosilicon the optimum speed is one revolution per 65 hrs.

Reversing of a small furnace was tested at the Chelyabinsk Plant during the production of commercial-grade silicon. The best results were obtained when the furnace turned 50° at a rate of 4° per hour.

The experiments established that during the rotation of the furnaces the technology of smelting should also correspondingly be changed. Thus in all cases it was found that the rotation of the furnace increases the consumption of electrodes. Sections of the top leading from the electrodes are more gas penetrable during rotation than sections leading to the electrodes (where the charge is compressed). The advantage of reversing prior to rotation in one direction was also established.

The participants of the school found that the best technology is applied at the Zaporozh Plant: good preparation of the charge (coke and quartzite) and charging machines are used. In addition to this, at one of the best furnaces of the plant the lowest useful phase voltage was noted between the electrode and the hearth — 63 v—which favors deep immersion of the electrodes into the charge. According to the estimate of the school, the electrodes at this furnace (as at certain others) were in the charge to a record depth of 1.2 m. In this case the distance between the lower edge of the electrodes and the hearth is 0.55 m. This is the least distance of all the furnaces examined by the school.

We point out for comparison that when smelting ferrosilicon of the same type of steel in the furnaces at the Chelyabinsk Plant the electrodes are immersed into the charge only 0.75 m, the distance between the electrodes and the hearth was 0.85 m. Here the useful phase voltage is higher (70 v); the quartzite used is large and unsuitable for machine charging. It is also significant that at the Chelyabinsk Plant 12 tappings are made per day and 18 at the Zaporozh Plant. At the Chelyabinsk Plant the tapping hole is closed off from the electrode mass by stoppers (cones) which must be burned through prior to tapping by an arc for which steel rods (12 kg / ton of 75% ferrosilicon) are consumed; tapping rarely continues for 40 minutes.

At the Zaporozh Plant the tapping hole is closed by clay stoppers; the consumption of steel rods in this case is only 6 kg/ton of alloy.

The Zaporozh ferroalloy workers have the highest qualifications. Here the senior steel worker (brigadier) of the furnace controls and directs the electrical regime, supervises the daily care of the charging machines, and he can change the charge. At the same time the rights of the senior steel worker at the Kuznets Plant are limited. He cannot direct the electrical regime and he does not have the right to change independently the charge of the heat.

Attempts are being made at the Zaporozh Plant to bring the electrodes closer together in order to improve the operation in the middle of the top. The smallest decomposition diameter of the electrodes is 2.43 m. The decomposition diameter of the electrodes at the Lipets Plant is 2.75 m, which, of course, hinders operation of the furnace.

The recommendations of the school will contribute considerably to the improvement of the operation of ferroalloy plants.

FOR THE PURPOSE OF SAVING FERROUS METALS

Hardening of Parts for Metallurgical Equipment – A large Reserve for Saving Metal

G. I. Shandrenko and M. V. Khitrik

All-Union Scientific Research Institute for the Organization of Ferrous Metallurgy

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At enterprises of the metallurgical industry large quantities of spare parts and interchangeable equipment are expended whose manufacture in the repair-mechanical shops annually costs tens of thousands of tons of metal and much capital.

The number of workers occupied in the repair-mechanical shops of the metallurgical plants for the manufacture of spare parts and interchangeable equipment is 12-14% of the total number of workers at these enterprises. The specific expenditures for the manufacture of these parts in the total sum of the expenditures of the metallurgical plants according to the production output is 10-12%. The working capital for spare parts and interchangeable equipment, as shown below, attains significant dimensions:

Plant	Total working capital, millions of rubles, for January 1, 1958
Voroshilov	77.2
Zaporozh Steel	83.2
Kirov	89.1
Dzerzhinskii	68.2
Azov Steel	76.5
Ilich	31.3

The total sum of working capital alloted for these purposes for the entire metallurgical industry is several billions of rubles.

One of the most effective methods of hardening parts is automatic hard facing of worn places under a flux layer.

It is possible to hard face rolls, spindles, bearings, metal-cutting blades, the bells of the top, the bell rods, the rollers of teeming machines, railway car chutes, trolleys, steam locomotives, electric locomotives, ladle cars, slag cars and electric bridge cranes, parts for crushers of various systems (hammers, rolls, cones), whips and rods of disintegrators, a large number of parts for various grinding systems, the feeders of excavators, bulldozers, etc.

Metallurgical enterprises attained positive results in the field of introducing automatic hard facing of rapidly wearing parts. Thus at the Voroshilov Metallurgical Plant after hard facing worn surfaces the service life of the forged skip ramp was increased by a factor of 2-3, the rollers of teeming machines by a factor of 2, and the durability of blades for hot cutting metal was considerably increased.

At the Dzerzhinskii and Lenin Plants the service life of the driving wheels of the transport-lift mechanism was considerably increased as a result of hard facing which in turn reduced the demand for ingots and the manufacture of new wheels.

At the Kirov Plant the necks of the rolling table rollers, the journals of the ramp axles, the charging cars, the rollers of the lifting platforms, blades for cutting metal, bands, driving wheels and other parts, were hard faced which increased their service life by a factor of 2-3.

At the Magnitogorsk Metallurgical Combine the operational life of the bells of the top was increased after automatic hard facing of them by a powdered electrode rod under a layer of flux.

At certain refractory, mining, and coke by-product enterprises the service life of the teeth of disintegrators was increased by a factor of 2.5 - 3, of crushing rolls by 4-5, etc.

However hardening and reconditioning of parts by the method of automatic hard facing is still not widely used at enterprises of the metallurgical and mining industries. Hard facing of worn parts at certain enterprises is not organized on an appropriate scale, is done at random, and by homemade methods.

The main measures to be taken in order to ensure expansion of the field of automatic hard facing are:

a) To equip the plants with hard facing equipment and apparatus;

b) To provide hard facing material;

c) To develop standard technological processes of hard facing parts;

d) To develop according to individual enterprises specific nomenclature of parts of equipment subject to

hardening and reconditioning by the automatic hard facing method;

e) To establish norms for the expenditure of parts that are being worn according to the individual types of equipment and for the unit expenditure of these parts per unit of production, taking into consideration their increase in durability due to hard facing;

f) To develop an incentive system for rewarding workers occupied with hard facing.

Scientific research institutes, particularly the E. O. Paton Institute and the All-Union Scientific Research Institute for the Organization of Ferrous Metallurgy, should directly participate in rendering technical aid to the enterprises for expanding the field of hard facing application.

The economic effectiveness of introducing automatic hard facing can be judged by the data of the expenditure of parts subject to hard facing.

Thus, at the Dzerzhinskii Metallurgical Plant the annual expenditure of such parts reaches 2000 tons, at the Zaporozh Steel Plant more than 2000 tons, at the Voroshilov Plant 1000 tons, at individual refractory plants 400 tons, at coke by-product plants 250 tons per year, etc. The total expenditure of such parts for metallurgical and mining equipment at enterprises belonging to the Dnepropetrovsk, Stalino, Zaporozh, and Luganskoye Councils of National Economy reaches 20,000 tons per year.

If we accept that the expenditures for hard facing will be 50% of the expenditures for the manufacture of new parts, then the annual savings will be approximately 20-25 million rubles. In addition to this, hard facing of parts will ensure a savings in metal, reduce idle times of equipment, increase the productivity of units, improve the quality of products, etc.

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CONCERNING AN IMPORTANT MATTER

P. F. Smirnov

Central Committee of the Trade Union of Workers in the Metallurgical Industry
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Incalculable riches are stored in the mineral resources of the gray Urals. In its southern part, Bashkiria, ores of ferrous and nonferrous metals have been mined and processed since ancient times. The products of the oldest Beloretsk metallurgical and steel wire plants and of the Tirlyanskii Plate and Sheet Mill have won a good reputation and are in wide demand both in the USSR and abroad.

Bashkirian metallurgy has changed beyond recognition during the years of Soviet power. Names of new mines and concentration factories appear on a map of the republic. Exhausting manual labor has been replaced by a powerful advanced technology which has made it possible to attain a high productivity of labor, which brought new socialist culture to production. The creative initiative and ingenuity of the Ural skilled workmen have greatly improved production efficiency. The number of their suggestions directed toward mechanization, facilitation, and creating labor safety conditions grows from year to year.

The first year of the Seven-year Plan, 1959, is especially noteworthy in this respect.

At the Beloretsk Metallurgical Combine about 2000 suggestions for improved production methods were introduced in 1959, which is 20% greater than the number of suggestions submitted in 1958. More than 1200 suggestions have already been introduced into production. This is 41% greater than in 1958. The total economic savings is 68% greater than in the preceding year and amounts to more than 7.5 million rubles. The sum of the authors' remuneration and prizes for their cooperation in the introduction of improved methods was more than 300,000 rubles, i. e., 55% more than in 1958.

All this testifies to the enormous enthusiasm, the creative spirit of the workers, engineers, and technicians and to their endeavor to make their contribution to the national struggle for fulfilling the Seven-year Plan ahead of schedule.

However, the trade union committees and the councils of the All-Union Society of Inventors and Efficiency Experts of many metallurgical enterprises of Bashkiria still do not stand at the head of the growing movement of efficiency experts and inventors. Now and then they overlook what is new in this movement and fail to grasp and disseminate at times very important matters.

In 1959 the council of the All-Union Society of Inventors and Efficiency Experts at the Beloretsk Metallurgical Combine (Comrade Askarov, Chairman) proclaimed a review-competition for the best enterprise of the combine in the development of an invention and

improved production method with the participation of many workers. All six enterprises participated in the struggle for first place.

The plant committee of the trade union and the plant council of the All-Union Society of Inventors and Efficiency Experts of one of the metallurgical plants belonging to the combine found a concrete method for mobilizing the collective for the struggle for first place in the review: they declared a competition for the best shop of the plant in the development of improved production methods, and in each shop competitions were organized for the best shift in improving production methods. Right here the regional committee of the trade union and the council of the All-Union Society for Inventors and Efficiency Experts should have seized this good beginning, should have organized a specific struggle for first place in the competition at each enterprise of the combine. However neither the chairman of the regional committee, Comrade Korolev, nor the chairman of the All-Union Society for Inventors and Efficiency Experts of the combine, Comrade Askarov, devoted attention to this wonderful initiative, and it is only as a result of regular summing up of the outcome of the review, of pointing out the best collectives of the shops that the plan for submitting suggestions for improvement of production methods was fulfilled in 1959 by 157%, and that the number of suggestions increased by 26% in comparison with 1958.

Other very useful actions of the Beloretsk metallurgists were not disseminated to metallurgical enterprises. The plant committee of the trade union and the council of the All-Union Society of Inventors and Efficiency Experts of the Beloretsk Metallurgical Plant, having assured an increase in the influx of suggestions for improved methods in 1959, did not rest on this. They set before themselves the task of introducing the maximum number of suggestions into production by the end of the year. They found a concrete form of competition between the shop collectives for the maximum introduction of the suggestions submitted. In particular, an inter-shop relay race was proclaimed at the plant for a challenge prize for the best organization in the introduction of suggestions. The plant committee of the trade union and the council in conjunction with the plant administration were able to bring the problems of the introduction of suggestions to the center of attention of the shop collectives and to organize an active struggle for the right to be the best in this important matter. As a result, the number of suggestions introduced in 1959 at the plant increased by 68% in comparison with 1958, and the remaining unintroduced suggestions carried over to 1960 were reduced to a minimum. The annual savings from the suggestions introduced more than doubled and amounted to 4.5 million rubles.

The regional committee of the trade union and the councils of the All-Union Society of Inventors and Efficiency Experts should have paid special attention to this form of struggle, new in Bashkiria, for introducing the suggestions of the efficiency experts, should have studied this practice and widely disseminated it among all collectives of the enterprises. However on this occasion the good work of the efficiency experts of the Beloretsk Metallurgical Plant did not go beyond the limits of the plant territory.

And it is the state and organization of the introduction of the suggestions of efficiency experts that causes concern in many metallurgical enterprises of Bashkiria. The administration of a number of plants decline up to 30% of the suggestions submitted and the introduction of those accepted is organized quite unsatisfactorily. Thus, Comrade Svetlitskii, quarry worker at the Beloretsk Combine Novii Sibay, suggested the installation of a knife switch for switching over the lighting from 127 to 220 v on the excavators made by the Ural Heavy Machine Building Plant. This suggestion was introduced only on three of the ten excavators operating.

The suggestion of Zuev and Bochetskii, workers at this quarry, concerning "the lift of drill bits on the working platform of a drilling stand" was introduced only on two stands out of 28.

There are many such examples.

In essence, there is no control at the combine for the introduction of suggestions. A random check recently conducted showed that there are some suggestions which according to reports are counted as introduced, but which actually have not been put into operation anywhere.

For example, skilled worker Comrade Voronin contributed a rather valuable suggestion, the introduction of which would considerably increase the service life of drums on BU drilling stands. The supervisor of the shop calculated that the savings from introducing this suggestion would be 53,000 rubles per year; it was recorded as introduced, and the author received his remuneration. Actually the suggestion was in no way introduced into production.

It is impossible to dispute that the activity of the workers, engineers, and technicians in finding improved methods of production increases from year to year at the metallurgical enterprises of Bashkiria. This is completely understood. It is in Bashkiria that life itself dictates the problems of the reconstruction of the old enterprises. Here is where creative thoughts unfold, here is where an abundance of work is available to the efficiency expert. But in spite of this, participation of the workers in the work of finding new, efficient production methods is lower here than at other metallurgical enterprises of the country.

Actually, at the Beloretsk metallurgical, steel-wire, and metal-working plants one out of every 11 workers participates in finding new production methods. And this index is considered the best. At the Mindyak

Ore Administration every fourteenth worker is an efficiency expert. One out of 12 participates in developing new methods of production at the Tirlyanskii Plate and Sheet Mill, the Beloretsk railroad, and the Tukan Ore Administration.

It is therefore surprising that the regional committee of the trade union of metallurgists, the councils of the All-Union Society of Inventors and Efficiency Experts of the Beloretsk Combine and of other metallurgical enterprises overlooked the remarkable beginning of the engineers and technicians of the open-hearth shop of the Beloretsk Metallurgical Plant which was directed to the wide inclusion of workers into the development of new production methods.

The engineers and technicians of the open-hearth shop of the Beloretsk Plant, enlisting in the struggle for the early fulfillment of the plan for the second year of the Seven-year Plan, answered the call for all engineering and technical workers of the Beloretsk Combine and city to develop new production methods and to enroll in this movement wide masses of workers. Each engineer and technician pledged to help workers develop not less than three suggestions for new production methods in 1960.

But this good beginning has grown lifeless not only at the combine but even in the open-hearth shop itself.

Now the Central Council of the All-Union Society of Inventors and Efficiency Experts and the Central Committee of the Trade Union of Metallurgists are conducting a review for the best enterprise in the metallurgical industry in the development of inventions and new production methods in which many workers participate and for the introduction of these suggestions. Active participation in this review should be at the center of attention of all trade union organizations.

The trade union committees and the councils of the All-Union Society of Inventors and Efficiency Experts of the metallurgical enterprises of Bashkiria still have not participated in the review. Here they intolerably prolonged its organizational part and still have not started practical matters.

Recently the Presidium of the Central Committee of the Trade Union of Metallurgists heard Comrade Korolev, Chairman of the Regional Committee, concerning the course of conducting the review. The Presidium of the Central Committee, in its decree, noted practical measures that were to be taken for improving the work of the regional committee in the field of organizing and conducting a review and for increasing the mass movement of inventors and efficiency experts.

It is to be presumed that this will help the trade union committees to overcome their indirect relationship with the outstanding movement of efficiency experts and inventors and to make considerable improvements in this most important sector of work.

FERROUS METALLURGY OF HUNGARY

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An article on ferrous metallurgy of Hungary was submitted to the editorial office of the journal "Metallurg" from the Embassy of the Hungarian People's Republic. Taking into consideration the interest of our readers in the metallurgy of the countries of the people's democracy, we are publishing this article.

The metallurgical industry of Hungary began to be developed in the 18th Century. It was then that the first blast-furnace and open-hearth shops were built.

In 1938, on the eve of the Second World War, pig iron smelting had reached 335,000 tons, and steel 647,000 tons.

Rapid industrialization of the country began after the war. For this purpose it was necessary to develop a technologically advanced ferrous metallurgy. By 1959 pig-iron production more than tripled in comparison with 1938 and steel production was almost tripled.

Before the Second World War, Hungary had only six steel casting plants and five plants with blast furnaces, but in 1959, 44 large-scale metallurgical enterprises employing 75,000 workers were counted in the country.

Ferrous metallurgy has developed at an extremely vigorous rate during the last ten years. Whereas in 1950 a total of 411,000 tons of pig iron were smelted, in 1959 this figure grew to 1,200,000 tons. Steel production during this time increased from 860,000 to 1,700,000 tons; the production of hot-rolled products comprising 400,000 tons in 1950 exceeded 1,000 tons in 1959.

In steel production per capita the Hungarian People's Republic stands ahead of Italy and Japan, however it still lags behind the German Democratic Republic, France and Austria.

Steel production per capita was 170 kg in the republic in 1959.

The metallurgical industry of Hungary melts approximately 2.5 million tons of iron ore per year.

A quarter of this amount is mined in the country and the remaining three quarters is imported, mainly from the USSR.

Manganese ore is another important raw material for the production of pig iron and steel. In 1959 Hungary extracted about 150,000 tons of manganese ore, which completely satisfied the requirements of the country.

Coke, which is necessary for the production of pig iron, was previously imported exclusively from abroad. But in 1954 coking of Hungarian coal began, and already in 1958 one fourth of the necessary blast-furnace coke was made in Hungary.

Even though prior to the war Hungary had 11 metallurgical enterprises, ferrous metallurgy actually did not begin to be developed in the country until 1950. Near the largest iron-ore deposit a powerful ore-beneficiation plant was built which has a crushing department, roasting furnace, and a department for magnetic concentration. In the last decade another beneficiation plant was put into operation, and sinter plants were built at the largest blast-furnace mills. In 1959 a plant which prepares red mud, a by-product of alumina for melting, was constructed.

In addition to this, the earlier operating blast furnaces were reconstructed and several large-scale furnaces with 700 m^3 volume each were built. The Danube Metallurgical Combine was put into operation at the city of Sztalinvaros. The blast furnace operations of this combine were mechanized and automated. The furnaces smelt approximately 3000 tons of raw material – ore, coke, limestone – per day.

The open-hearth method of steel production was introduced in Hungary at the end of the last century.

In recent years in Hungary, as in other countries, technical innovations have begun to be used for the production of steel. In particular, continuous teeming was introduced which increases metal production by 10-15% since on the continuous teeming installation, not ingots but blooms are produced which can be sent directly to the rolling mills. Vacuum treatment was widely introduced, thus considerably increasing the quality of steel and alloys.

Hungarian ferrous metallurgy, expanding the assortment of products, began the production of a large number of different steels and alloys. Many metallurgical plants manufacture stainless and acid-resistant steels and steel sheets, free-cutting, high-speed steels and also especially strong steel.

Precision casting was developed in order to satisfy the requirements of one of the most important branches of Hungarian industry – communications engineering. Powder metallurgy is developed on a smaller scale in Hungary.

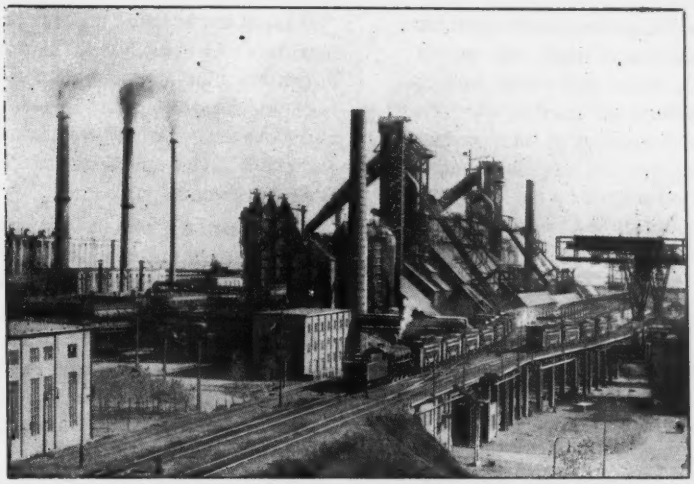

Fig. 1. Blast Furnace of Danube Metallurgical Combine, Sztalinvaros.

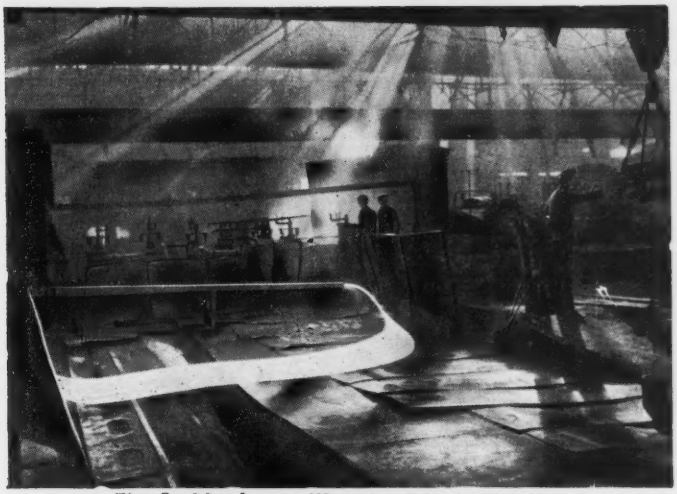

Fig. 2. Merchant mill at the plant in Kepek.

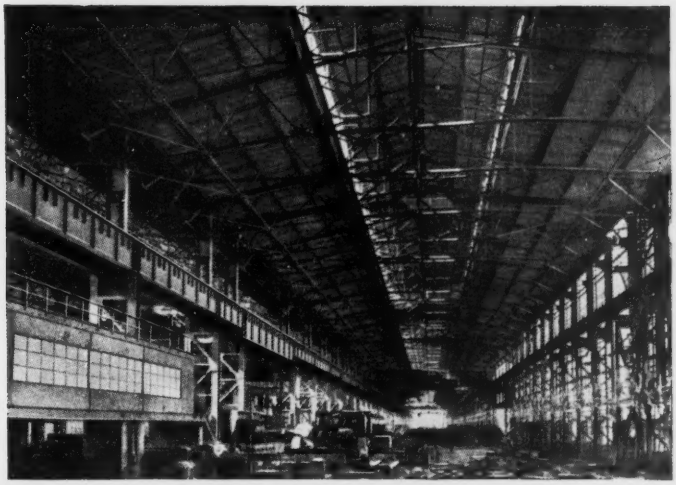

Fig. 3. Hot-rolling shop being built at the Danube Metallurgical Combine.

For several years the Hungarian metallurgists have been developing the production of steels with special properties, of thin sheets, and of cold-rolled products. The solution of these problems are aided on one hand by the introduction of a new technology of steel production – continuous teeming, vacuum metallurgy, casting process, etc., and on the other hand by the construction of new metallurgical enterprises designed for cold working of metals. Such reconstruction of the Hungarian metallurgical industry has already started. A hot-rolling mill more than half a kilometer long will be put into operation in 1960 at the Danube Metallurgical Combine; cold-rolling shops constructed according to the latest work in technology with a capacity of 50-60,000 tons per year will be put into operation at this combine during the second Five-year Plan (1961-1965). Sheet and wire mills will be put into operation there also. The introduction of these facilities will increase by 80% the production of metal for machine construction by 1965.

The second Five-year Plan provides for an increase in pig iron production to 1.6 million tons by reconstructing the existing blast furnaces and in the production of steel to 2.4 million tons. The production of coke will be doubled.

Rapid and accurate analysis of materials plays an important role in each metallurgical converter. At the largest metallurgical enterprises measurements and investigations are conducted by means of radioactive isotopes, but other methods are used along with this. Thus, ultrasonics have been used since 1957 in order to determine the structure of steel.

Hungarian engineers and scientists have manufactured many instruments which are used for nondestructive investigation of materials. The continuous Zoltan-type detector for sheets, which received the grand prize at the Brussels Exhibition, ensures investigation and classification of 2-5 ton sheets per hour. The installation of a Intactor-Microport-Minor designed by Ishtvan Meshter makes it possible to investigate rapidly the structure of metallic articles.

Only several years ago Hungary began production of equipment for the metallurgical industry. Now it is already exporting it to many foreign countries. In 1959 electric-arc furnaces of Hungarian make were purchased by Indian metallurgical enterprises. Now complete equipment for a large tube-rolling plant is being manufactured for a foreign order.

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosénergoizdat	State Power Engr. Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LÉIIZhT	Leningrad Power Inst. of Railroad Engineering
LÉT	Leningrad Elec. Engr. School
LÉTI	Leningrad Electrotechnical Inst.
LÉTIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MÉP	Ministry of Electrotechnical Industry
MÉS	Ministry of Electrical Power Plants
MÉSÉP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTi	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOÉ	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIÉL	Central Scientific Research Elec. Engr. Lab.
TsNIÉL-MÉS	Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIÉSKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZÉI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us - Publisher.